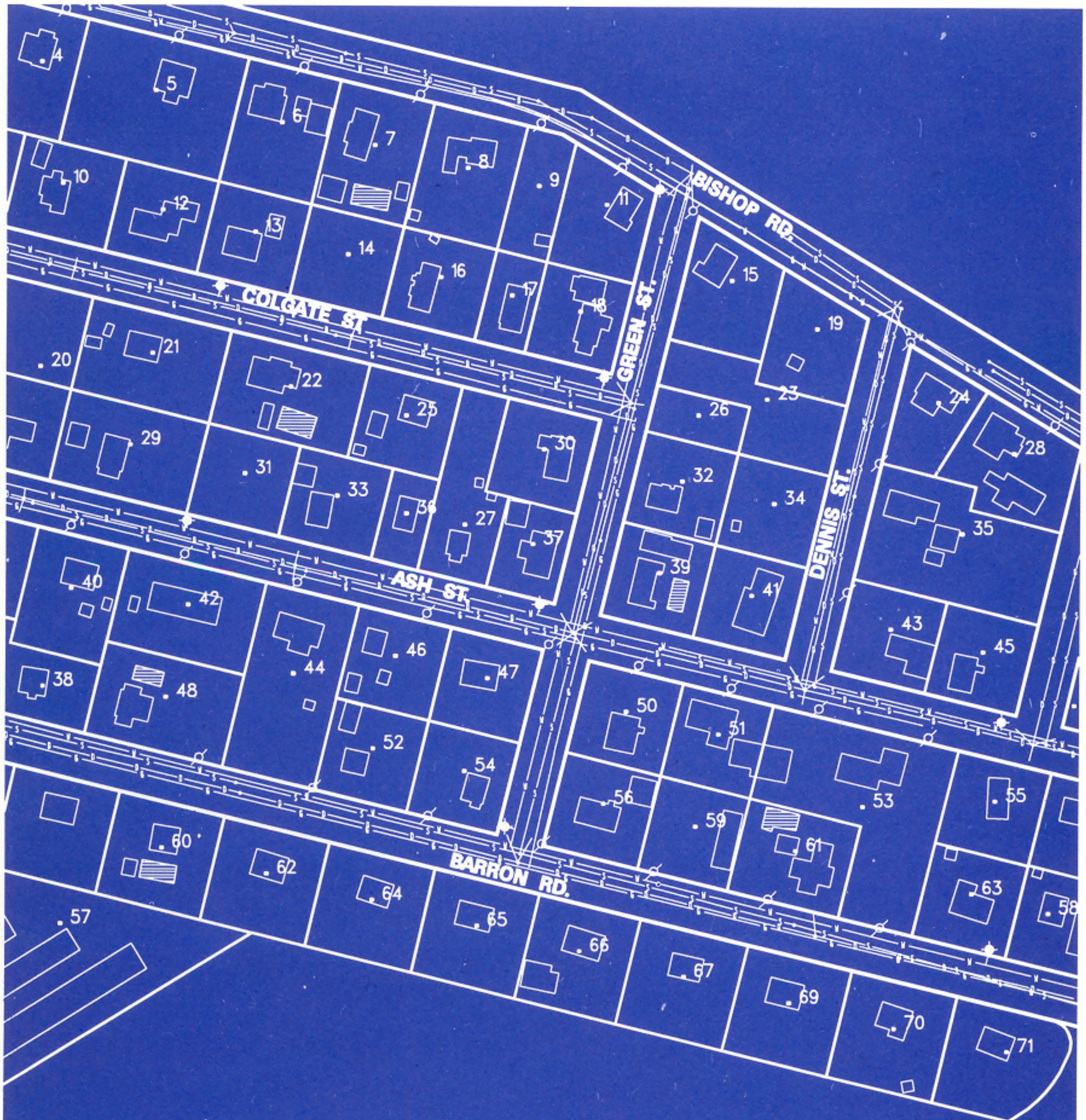
GIS GUIDE BOOK

FOR NEW HAMPSHIRE MUNICIPALITIES



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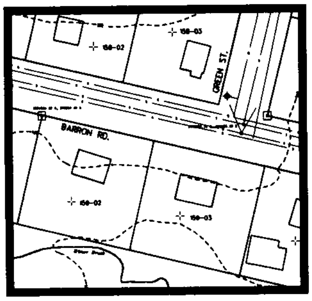
GIS GUIDE BOOK

FOR NEW HAMPSHIRE MUNICIPALITIES

State of New Hampshire,
Stephen Merrill, Governor

New Hampshire Office of State Planning,
Jeffrey H. Taylor, Director

December, 1994



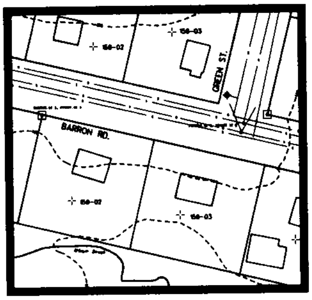
Preface

Over the past several years, the Office of State Planning has received numerous requests from local officials in New Hampshire for guidance concerning geographic information systems (GIS) technology and its uses by municipal government. This guidebook was written in response to those requests.

The Office of State Planning is charged by the New Hampshire Legislature with the responsibility for providing technical assistance and information to municipalities, with the cooperation of other State and regional planning agencies, in the following areas:

- Making available geographic data in the State's geographic information system (NH GRANIT) for local planning and growth management purposes; and
- Recommending standard procedures for establishing accurate, large-scale mapping to support municipal administrative functions, such as tax assessment, public facility management, and engineering (RSA 4-C:8,IV).

The future of GIS for local government is bright. With advances in computer software, coupled with continuing lower costs and increasing power of computer hardware, access to GIS is within reach of most New Hampshire municipalities. The access may come in many forms, ranging from working with generalized data housed at the State or at regional planning commissions, to working with consultants, to implementing full-scale, in-house systems. Whatever option is selected, this guidebook offers suggestions and guidance on how to take advantage of GIS technology that will benefit both the municipality and its citizens. Because each community faces somewhat different concerns, such as cost or simply the fear that a GIS would be just another nice-to-have, but unnecessary, system, we provide a range of solutions to address most of these concerns.



Acknowledgements

The preparation of this guidebook involved many individuals representing a variety of disciplines and public- and private-sector organizations within New Hampshire. The contributors include the Municipal Engineers Council, NH Land Surveyors Association, NH Planners Association, NH Assessors Association, University of New Hampshire, NH Department of Transportation, and other State agencies.

A committee worked on the overall development of the guidebook, and other individuals reviewed the draft document and provided comments. Without the expert assistance of all contributors, whose names are listed below, this publication would not have been possible.

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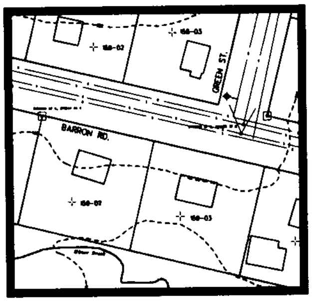

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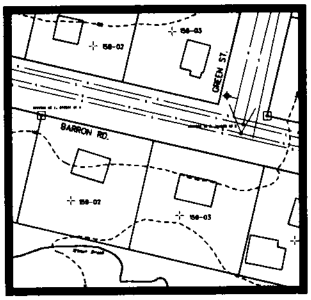


Introduction

Guidebook Objectives

This guidebook is a non-technical introduction to Geographic Information Systems (GIS) and their use by municipal governments in New Hampshire. It provides a primer on important cartographic and geographic concepts underlying GIS technology and its use by cities and towns. The guidebook offers suggestions and additional sources of information to local officials considering or planning a GIS to help them make well-informed decisions and thereby avoid potentially costly mistakes.

Who Should Read this Guidebook?

Although this guidebook is useful to general readers, its intended audience is local officials, such as planners, engineers, school district administrators, emergency teams, surveyors, assessors, and others who are responsible for producing, managing and using geographic or mapping information. As the ultimate users of a GIS, it is important that these individuals understand the value of this technology to the operation of their departments and the linkages it provides to other departments within and across municipal jurisdictions.

What is a GIS?

A GIS is a powerful computer-based technology that allows users to collect, manage, analyze, manipulate, and display geographic information. This information can then be used to support and facilitate on-going activities, and/or to expand the scope of the decision-making process. For example, a GIS can be used to evaluate the suitability of proposed sites for a new school by considering such geographically based factors as access to main roads, proximity of blocks of school-age children, the community's projected population growth, and natural features, including the suitability of the site for development.

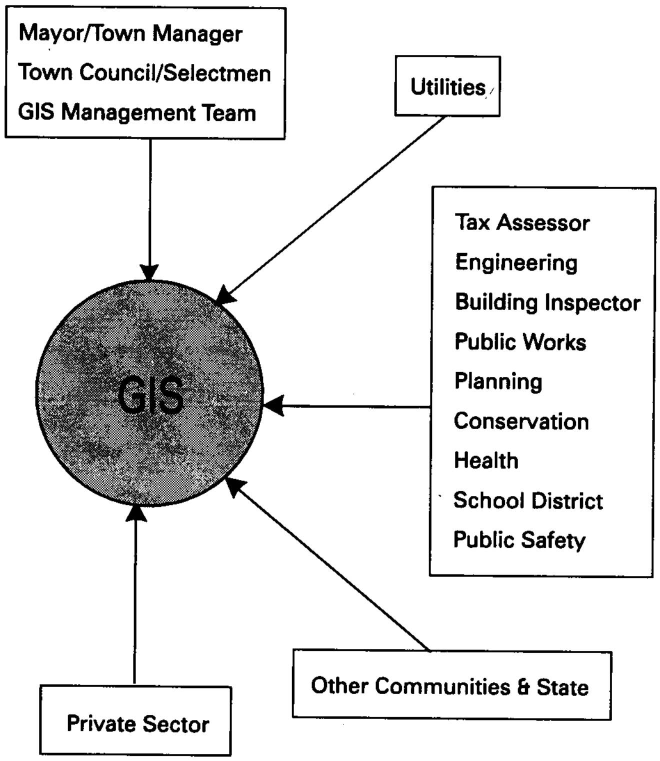


Figure 1. Linkages Through GIS.

For municipalities, a GIS is especially useful for:

- Public works
- Engineering
- Tax assessment
- Conservation
- Zoning
- Utilities
- Emergency planning and response
- Health and safety
- School bus routing
- Economic development
- Land use planning
- Voter registration

As shown in Figure 1, a municipal-wide GIS also promotes interdepartmental communication by linking departments through a central database.

What Are the Benefits of a GIS?

GIS offers many benefits to local government functions by enhancing their ability to store, manage and display geographic data in graphic and non-graphic form, by streamlining their ability to produce accurate and timely maps and engineering drawings, and by improving their ability to analyze and interpret mapped data. GIS also helps employees become more efficient and productive, and may reduce overall department operational costs. Municipalities are also able to provide timely information to the public in a format that may be readily tailored to the individual customer.

Several of the most important benefits are discussed below.

Analysis is Easier and More Detailed. The ability to conduct new and enhanced analyses are two important benefits a GIS provides. Once installed and operational, the GIS allows municipal departments to cost-effectively perform a range of projects, including proposed development projects, site selections, demographics, and utility location. For example, with the availability of data on road surface conditions, time and locations of accidents, traffic engineers can conduct accident incident analyses to determine high-accident locations and periods.

In addition, various types of simulations, such as an environmental emergency, can be conducted by accessing data in the GIS database. For example, to model an oil spill, the user might access and display information about where booms and other gear are stored, the location of the spill and the environmental sensitivity of the spill area. It is also possible to simulate the flow of the oil over time.

Improved Availability and Distribution of Public Information. Providing information to the public is a primary function of municipal departments, so it is critical that it be provided at minimal cost. For example, many land-use projects, such as retail and residential developments, require that surrounding land owners be notified of forthcoming construction and changes. Using a GIS, departments are able to quickly create abutters lists, public notices, permit tracking and voting district change notices.

Improved Efficiency in Updating Maps. Continual updating of mapped information for monitoring municipal development is another routine function that can benefit from a GIS. As a community grows, maps must be updated. By maintaining a central GIS database, one ensures that all municipal users are accessing the current (and correct) version of a given map.

When a municipality implements a GIS, it will be able to determine the amount, location and type of land-use change. Monitoring this information will result in a keener understanding of land-use trends within the community. Land-development planning, then, will take place with greater care then previously possible, resulting in more appropriate decisions.

Improved Capability to Assemble Spatial Data. Many New Hampshire municipalities have expressed a need to more effectively assemble data by area. For example, individual departments may need to know the location of specific populations, such as low-to-moderate income families, or the elderly, or school-age children. The availability of U.S. Census Bureau data and New Hampshire GRANIT System data compatible with a municipality's GIS will facilitate this type of demographic analysis.

Shareable Database Connects All Departments. Implementing a shareable, municipal-wide GIS may be a municipality's ultimate objective. By shareable, we mean that all departments can access map data in the GIS's single map set. This capability eliminates the need for departments to maintain separate map records, reduces the redundancy associated with updating maps containing data from several departments, and makes map revisions more efficient and less costly.

For example, an assessor might need data from the engineering department database in order to update tax parcel information. Using a manual or department-only database makes this task time-consuming and expensive, because of all the searching employees must do in order to personally collect data from other departments. When the changes are made, the new map data remain within a specific department's files.

Having access to all map data from all departments streamlines the task of updating and revising individual maps. The GIS ties all departments together through a central database, and improves the flow of information between and among departments. Because each department has its own computer or terminal, networked to a central database, employees do not have to move from their offices in order to collect data they need from other departments.

Facilitates Policy Formulation. A municipality can use a GIS to efficiently coordinate management functions and policy formulation. Various scenarios may be analyzed, and alternatives repeatedly tested, to derive and refine the most appropriate solutions to specific situations. For example, a GIS can be used to analyze the effects of voting redistricting, or to portray thematically the effects of zoning patterns. Land-market value effects, which might be caused by the construction of a land fill or office park, can also be analyzed.

Although the benefits of a GIS are easy to identify, they are sometimes difficult to quantify. Nonetheless, savings will be realized by reducing the time and cost of collecting and using standardized data, and through improved individual productivity. Savings derived from other less concrete GIS benefits, such as improved policy analysis or broadened analytical scopes, are even more difficult to estimate. Nevertheless, if municipalities take careful, systematic measures to plan, design and implement a GIS that meets their immediate and long-term information needs, they may realize both tangible and intangible benefits.

Issues and Risks

Just as there are substantial benefits to be gained from a GIS, there are associated issues and risks that local governments must recognize, including those discussed below.

GIS Objectives: What do you want the GIS to accomplish for you? When considering a municipal GIS, it is important to define exactly what your objectives and expectations are for the system. In a real sense, these form the basis for a decision to implement a system. For example, with no clear statement of objectives, it is possible to design a system that meets the needs and expectations of no one, and that quickly becomes under-utilized and stagnant.

Funding Constraints: Can we afford to implement a GIS? It is obvious to readers that a GIS costs money to design, buy, maintain, and upgrade periodically. Given the funding constraints all communities work under, local officials must consider two basic questions: "Can we afford to implement a GIS?" and "What will be its projected costs for software, hardware and data maintenance over five to ten years?" Purchasing a system now might be feasible, but will there be sufficient funding in the years to come? Such considerations must be carefully reviewed and decided well before any decision to proceed is made, usually as part of a long-term implementation plan.

Base Mapping: What scale and level of accuracy should be chosen? A major cost of GIS is the database development. A community must consider the long term usefulness of the base map scale and geodetic control selected, since its accuracy and resolution will largely determine the breadth of uses to which the database can be put. Highly accurate, large scale base mapping for a community, developed by appropriate techniques and carried out by qualified firms, is expensive, but should be cost effective in the long run. Licensed surveying and mapping professionals, whether on staff or as consultants, can play a critical role in assuring the quality and accuracy of the spatial database, both in the initial data gathering and in the updating and maintenance phases. The N.H. Land Surveyors Association can provide municipalities with additional information. If a town decides to automate existing parcel maps with little or no ground control as a basis for its GIS, the resulting database will be limited in its application to other municipal functions.

Liability: Does a municipality risk increased exposure to liability by putting more and more data into digital form? The answer to this question is a difficult one in that it involves two fundamental issues:

- The public's right to know; and
- The municipality's right to protect itself and its authorized representatives from litigation over the misuse of the data it provides to individuals or organizations.

Regarding the first issue, local government records are considered "open or public records" to which the public should have access. This right is supported under various open-record and freedom of information acts. The dilemma municipalities face is striking a balance between the public's right to know, and the right to protect the records from potential unauthorized use or misuse by those who purchase them. This issue leads to the second major issue.

The public must have access to digital and paper records. However, the use to which the data are put raises two important legal questions: "Do purchasers of the data have the right to use the data in any way they see fit?" And, "Does local government protect itself from litigation when purchasers of the records misrepresent the data?" To minimize potential litigation, a community must specify what limitations pertain to the data use. These limitations might address accuracy, completeness and possible errors, and might involve applying disclaimers as in "for planning purposes only, not to be used for legal boundary determination or for regulatory purposes." Including this disclaimer in the bill of sale or agreement with the purchaser should protect both the municipality and its representatives from litigation.

Political and Public Support: Who can you depend on for support? Implementing a GIS should not be an heroic act by one person. Support is needed from a variety of individuals and constituencies within the community. Identifying "champions" to educate others about GIS is critical, and is a strategy that will work to your community's advantage in the long run. The process will allow many people to voice concerns and suggestions before any commitment to a GIS is made. In a sense, they will have a "piece of the action" and, by having it, commit to the system's implementation. A "Win-Win" outcome is what you must strive for!

What System to Buy: Customized or off-the-shelf? Enthusiasm for a new technology often clouds an individual's or a community's perspective. Initially, municipalities may buy more than they need and, by doing so, overwhelm the budget and the system's potential users. Vendors and consultants may contribute to the confusion by recommending systems that are too sophisticated and too expensive. Yes, it would be nice to purchase a customized GIS, but would an off-the-shelf, easily expandable system serve a community's initial needs just as well?

Planning: Do you have a long-term plan for implementing a GIS? If your community decides to implement a GIS, it is essential to devise a long-term plan for guiding the system's incremental implementation. The plan covers a variety of items, such as projected costs for data and database development, conversion of existing data, software, hardware, staffing, training, maintenance, and the like.

User Involvement: What role will the user play in determining needs and requirements?Before committing any funds to a GIS, it is essential to identify and define the needs of current and potential system users. These individuals will provide the basic information about system uses and requirements, which will provide the basis for system design. As explained in Chapter 3 of this guidebook, interviewing users is a critical activity that will help local officials make a well-informed decision to proceed or stop. If a proposed GIS cannot meet the immediate and future needs of users, then it should not be implemented.

User Training: How will this be accomplished? For a variety of reasons, training is often a neglected activity. Yet, if a municipality has a GIS in place but no employees who can use it effectively, then much money will have been wasted. A training plan should be incorporated into the long-term implementation plan and should cover such items as the learning needs of users, and the skill and knowledge requirements to operate the system efficiently. The plan should incorporate a training timeline, as well.

In addition, training should not be thought of as a one-time event. Rather, it has to be a continuous process so that users will be able to upgrade their own skills as the GIS is upgraded periodically and as new technology becomes available.

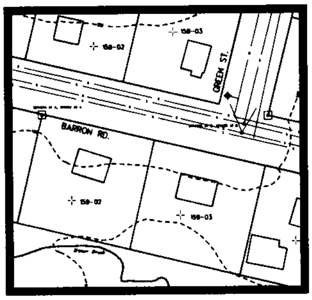
These issues and risks represent critical areas which must be dealt with carefully and systematically. If they are avoided, those engaged in a municipality's GIS project may be faced with endless frustration and the eventual failure of the project.

Guidebook Organization

Because this guidebook is a non-technical introduction to geographic information systems technology and its use by local government, it presents basic concepts and information. Although it would be helpful if readers have some knowledge of computer systems and applications software, it is not necessary.

This guidebook is organized as follows:

- ***Chapter 1*** presents a series of actual and hypothetical applications of GIS for municipalities as a way of explaining the potential of this technology.
- ***Chapter 2*** provides a brief explanation of essential concepts and technical terms which are the heart of GIS.
- ***Chapter 3*** describes a recommended process local government may use for implementing a GIS.
- ***Chapter 4*** provides basic information on choosing hardware and software for GIS.
- ***Chapter 5*** describes the procedures for setting up a GIS's tabular and spatial elements.
- ***Chapter 6*** addresses existing sources of data, which may be useful for a municipal GIS.
- ***Chapter 7*** deals with technical considerations of base mapping and geodetic control for a GIS.
- ***Chapter 8*** summarizes the contents of this guidebook and discusses the future of GIS technology for towns, cities, and regional planning commissions.



Chapter 1.

Municipal GIS Applications

Introduction

The Introduction to this guidebook briefly described the value and benefits of a GIS to municipalities. This chapter examines potential applications for a municipal GIS, and presents examples of GIS development efforts underway in several New Hampshire communities.

Today, local government faces the critical problem of efficiently managing ever-expanding volumes of data to provide decision-makers the options they need for informed policy making. In this period of economic belt-tightening, balancing the competing demands of processing more paperwork with fewer employees can prove time consuming and costly.

To resolve this dilemma, local government is turning to the use of cost-effective computer technology. Text processing, database management and spreadsheet software, coupled with powerful and inexpensive desktop computers, have become commonplace in many town and city offices. GIS is recognized as another computer tool in this family and an integral part of organizing, storing and retrieving municipal records in both graphic (maps) and non-graphic (text or tabular) form.

Consider the importance of geographic information to the management of a community. Among other matters, municipal government is responsible for the functions described below.

Legislation and Administration. These functions include maintaining records of annual meeting votes to accept roads or to purchase property, budget planning, appropriations for land-related projects, and providing information for policy decisions and projected impacts.

Information Storage and Retrieval. Managing documents, such as property ownership records, municipal lands inventories, zoning and building permits, circulation of library collections, vital statistics, population counts and census data is a vital function for which all municipalities are responsible.

Land Use. This basic activity involves maintaining records of land-development approvals and conditions imposed by the planning and zoning boards, historic district commission, and other local, state, or federal agencies. Other responsibilities include community master planning, zoning and road map production, and watershed and wetlands conservation.

Property Taxation. The responsibility for assessing and collecting taxes is vital to a community. Consequently, a town or city must assess land and building values, update tax maps, prepare and send out property tax bills and then collect taxes, information, and prepare new tax base projections for budget purposes.

Infrastructure. Municipal government is responsible for the construction and maintenance of town buildings, roads, storm drainage, sewer/water lines, recreation and cemetery facilities. Municipal government also manages public easements, detention basins, curb cut permits, and vehicle fleets.

Public Safety. Municipalities are responsible for public safety activities, including emergency response by police, fire, ambulance and rescue squads, as well as managing records on gun ownership, hazardous materials/waste storage, incident and accident reports, fire ponds, and restaurant inspections.

Education. Besides educating children, local goverments are responsible for projecting school-age populations, locating suitable land parcels for future schools, and planning school bus routing.

To fulfill each of these responsibilities and to make appropriate decisions, local officials frequently ask questions, such as:

- Where is that?
- How close to ___ is that?
- How large an area are we talking about?
- How many residences are within this distance of that facility?
- How much open space or what kind of development do we have in that area?

A GIS with a well-developed database component can deliver answers to questions like these quickly, with objectivity, and in a variety of ways. Without access to a GIS, many complicated questions might go unanswered because of the time and effort required to develop the information manually. Equally important, some questions may not even be posed because of recognition from the outset that the answer can not be retrieved using standard techniques.

Using GIS Data

Municipalities will find that they use the data in the GIS in two basic ways:

- To retrieve and display existing data (query), or
- To generate new information by manipulating existing data (analysis).

Queries may be quite simple, such as displaying in mapped format all properties on a particular street accompanied by a printed listing of all associated tabular information. Based on the associated information, the user might narrow the request to display only those properties valued at $200,000 or greater. Given this subset of properties, the user might then request that the last names of the homeowners and the number of bedrooms per home be printed on a customized listing. Queries on a well-designed and well-constructed database can become quite sophisticated and complex.

Analysis takes existing data and goes one step further to answer "What if?" questions. For example, a city may wish to encourage commercial development. A GIS analysis might involve displaying all land parcels within the current commercial zones, and then rating their developability based on such factors as percentage of land without wetlands and steep slopes, and the parcels' accessibility to transportation corridors. Reports based on analysis of these factors might influence the local officials to pursue zoning changes or other policy recommendations.

Whether the user is querying or analyzing or, as is frequently the case, some combination of the two, a GIS can provide the necessary tools to visualize the situation and do it quickly and in a convenient format.

The rest of this chapter is divided into two parts:

- A detailed discussion of common queries that users can perform with a GIS to support everyday activities of individual municipal departments; and
- A description of a typical GIS analysis that illustrates many GIS capabilities.

GIS Queries: A Department Look

As individual GIS applications are discussed, bear in mind that GIS data are actually put to their most powerful use when they are shared among departments. Sharing these data creates opportunities for more reliable and standardized information on which to base municipal decisions.

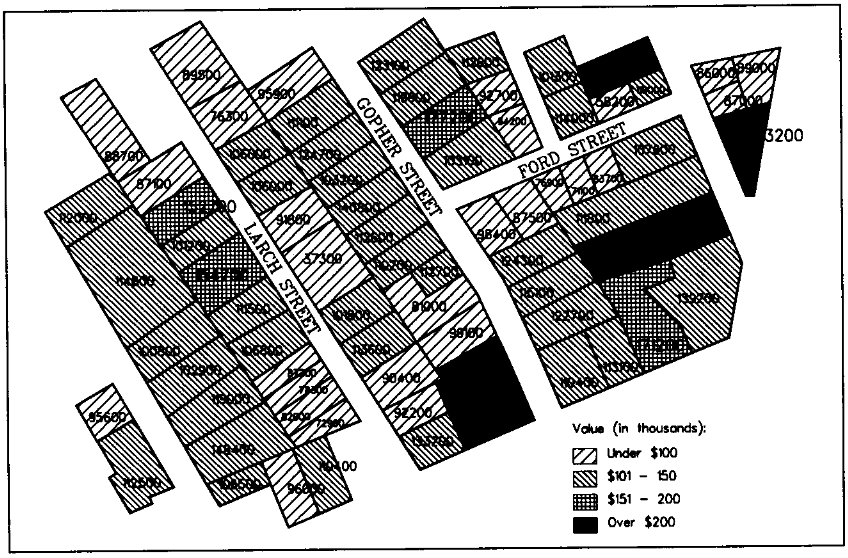


Figure 2. Query by Total Value in Thousands

Assessing

Along with municipal base map layers (streets, roads, railroads, bodies of water and drainage), are available, the cadastre or property data are frequently of greatest interest to a community. With the parcel boundaries and associated parcel characteristics in digital form, a variety of questions may be posed. Users may request that the answers be furnished in either mapped or tabular form. For example, users can produce maps that show the locations of parcels in current use, or, through levels of shading, different ranges of property values throughout the municipality, as illustrated in Figure 2. Another common task is the creation of an abutters list, with tax map block number, owner's name(s), registry book and page, land value, zoning district, and so on.

Some New Hampshire communities have included building roof outlines (building footprints) obtained from aerial photography. Once these are mapped and automated users may highlight individual buildings based on assessor's records, such as age, style, and total area. Figure 3 is an example of a query of buildings by age. The data requested are only limited by the source data in the GIS database.

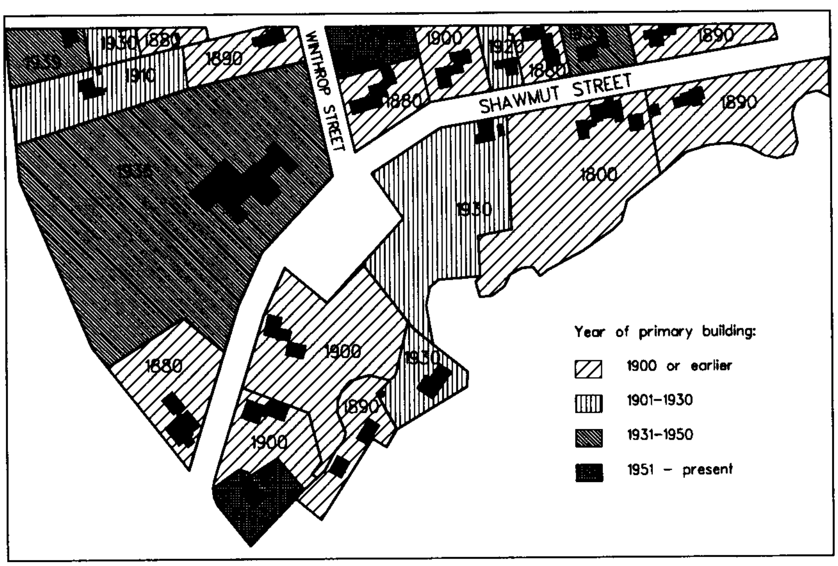


Figure 3. Query of Parcels by Year Building Constructed

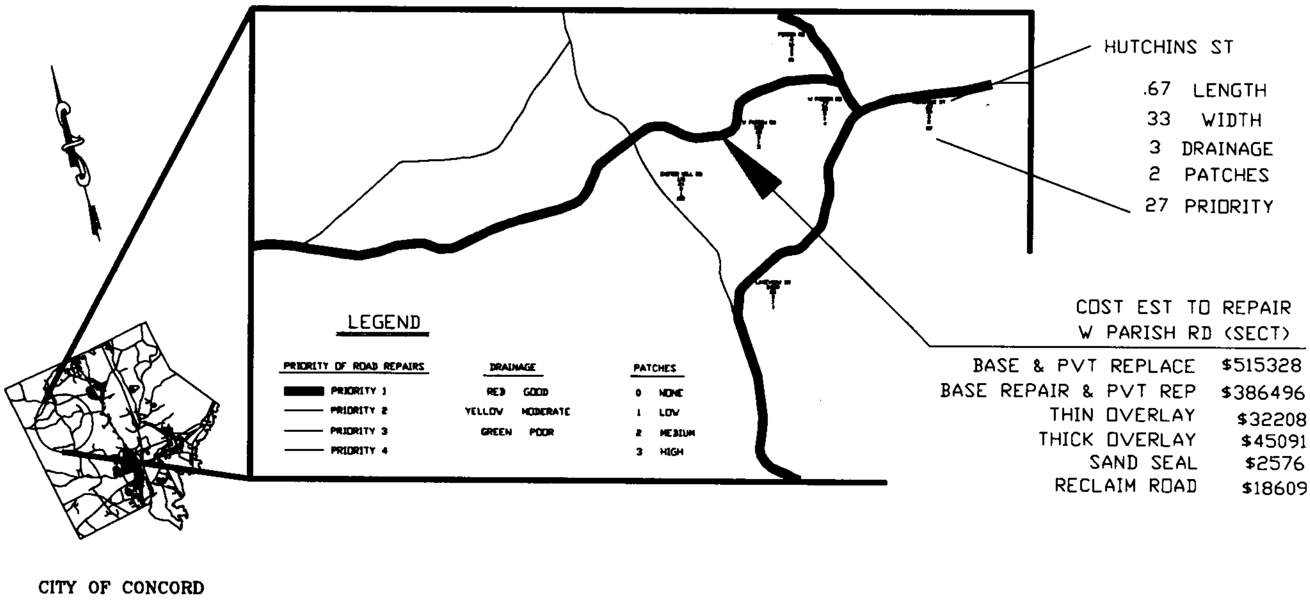


Figure 4. Pavement Management: Estimating Road Repair Costs

Public Works

An experienced public works official frequently knows by memory the location and condition of public facilities in the community. By making the appropriate queries of the GIS, any user can display the physical characteristics of these facilities in mapped form. Imagine the usefulness of being able to determine the length, surface area and pavement condition of all roads, and of producing a color-coded map where roads are displayed based on combinations of these three parameters. This capability is useful for identifying specific patterns in road usage and road deterioration, and for prioritizing (and consolidating) road maintenance projects.

Concord's municipal GIS database, for example, includes a number of public works layers – water service, sewer service, and roads. These data, along with a pavement management application, allow users to select streets based on types of pavement cracking, drainage quality, and so on, all of which can produce a priority ranking for repair. In addition, on-line repair cost estimates can be calculated and displayed on a map showing the roads in question.

Although such a GIS is no substitute for a "DIG-SAFE" call, it can be used to raise warning flags regarding underground and surface facilities. For example, if a homeowner intends to install a new well, he/she might request that a GIS query be executed. If water mains or electric lines are present near the area of interest, the GIS can act as a reminder to the individual to take the necessary precautions.

Police

The nature of police work lends itself to GIS analysis because nearly every activity has a geographic component. Traffic accident reports, for example, are generated by police officers and, in the case of Concord, the data are then entered into the GIS database. The value of these data expands as they become part of the GIS database. First, they become readily accessible and to other departments in the community. Second, the data may be viewed in combination with additional GIS data layers developed by other departments. Public works, for example, can determine if there is a relationship between accident location and road surface conditions, signage, signalization or roadway alignment, or traffic volume as shown in Figure 5.

Keeping track of crime and traffic violations is another useful application of a GIS. Recording the locations where accidents occur most frequently might influence where officers are stationed during subsequent periods. Similarly,

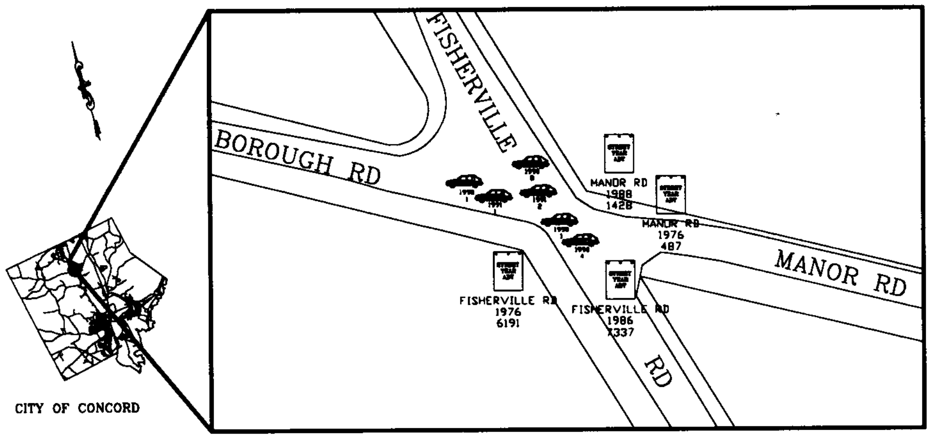


Figure 5. Traffic Counts / Accident Locations

knowing where weapons and ammunition are stored within the community can help both the police and the fire department when responding to a call or during their routine duties.

Fire

When a fire emergency is called in, the fire department could use the GIS to display critical information about the site. For example, a user could determine the type of structure (from the Assessors records), the potential presence of ammunition (from the Police Department records) and/or hazardous materials (from Fire Department records), the locations of hydrants (from Public Works records), and previous incidents at that location (from Fire Department records).

While the information is being retrieved, the team could still respond immediately to the emergency. While en route to the site, the dispatcher could communicate the information to them using cellular phone technology.

Enhanced 9-1-1 System

In January 1993, New Hampshire Senate Bill 441 became effective. This bill established an Enhanced 9-1-1 System (E911) as the statewide primary emergency telephone number in the State of New Hampshire. The purpose of the E911 is to improve emergency communications procedures to reduce response time for emergency calls for police, fire, medical, rescue, and other services. Each municipality is encouraged to establish accurate street names and numbering to aid in the efficient dispatch of emergency services.

An E911 system is an important capability that can be tied to a GIS and, thereby, greatly increase the efficiency with which 911 calls are handled. For example, calls made through the E911 system can be automatically routed to the GIS, which can then display critical information,

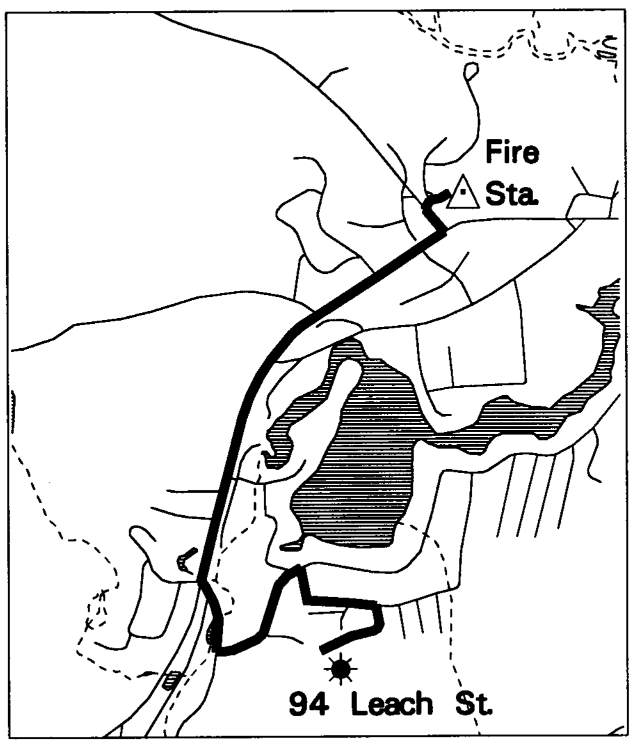


Figure 6. E911 Map

including the address and information relevant to that address, such as the presence of ammunition or other hazardous materials. A map of the surrounding area can also be displayed and the address of the emergency is highlighted on the screen display, as figure 6 illustrates. Using this information to guide decisions, the dispatcher can then query the GIS to identify the locations of response teams and then determine the quickest route they should take to the scene.

To be effective, an E911 system must be based on a uniform street-naming and property numbering system. Although some communities have expressed concern about changing street names and address numbers, there is a powerful argument in favor of such changes: Quick responses to emergencies save lives and property. An Enhanced 9-1-1 System linked to a GIS is the most effective means for accomplishing these objectives.

School

School departments or districts can benefit in several ways from a GIS. For example, bus routes can be planned based on the geographic distribution of student populations and the road network. Other GIS analyses might include the evaluation of alternative locations for future schools, or the generation of a map showing all land parcels within the "Drug Free School Zone." As an instructional tool, a GIS can be used to teach a number of disciplines, including social studies, geography, and mathematics.

Planning and Zoning

While master plan development can employ the more sophisticated analytical capabilities of a GIS, day-to-day planning of department activities can use simple queries. Information that allows a planning board to evaluate building proposals for conformance with land-use regulations may be generated. Zoning districts, for example, can be located and their allowable uses identified. Abutters can be identified and notified of zoning changes. Site plan reviews and subdivision proposals can be produced from the parcel database. A typical abutters list is shown in Figure 7.

Another set of planning applications involves the use of socio-economic data. Data may be extracted from the U.S. Census Bureau TIGER (Topologically Integrated Geographic Encoding and Referencing) files, a special database that provides the outlines of all census blocks, block groups, and higher geographic groupings. The graphic data may be linked to standard census tables. For example, accessing these data permits users to obtain, for example, information about the location of neighborhoods with predominantly low and moderate income residents, areas with a high percentage of rental units, or areas with the largest numbers of school-age children.

Lot #	Last Name	Address
17	FRENCH	5 MARDEN LA.
Abutters:		
15	WALTERS	996 KRONE RD.
16	SCATA	994 KRONE RD.
10	DREW	10 MARDEN LA.
14	PISTEY	7 MARDEN LA.
6	DUVAL	3 KRETOVIC CT.
18	HARRIMAN	3 MARDEN LA.

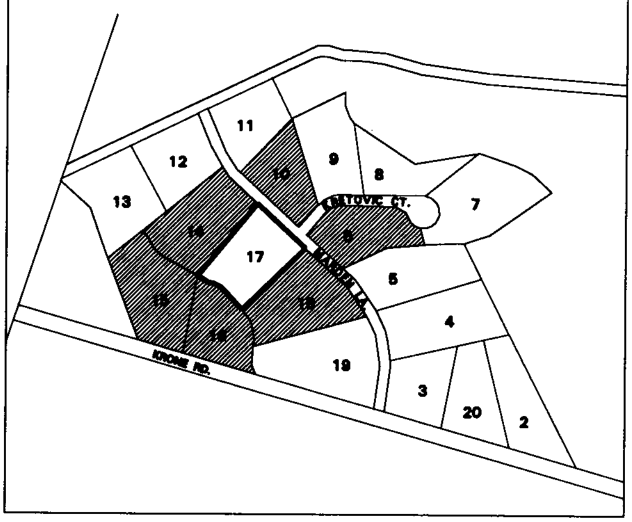


Figure 7. Abutters List

GIS Analysis in the Planning Process

As discussed in the opening of this chapter, analysis involves the examination of existing data to produce new relationships between and among data elements. Analysis can be performed by any municipal department. For example, the Police Department may seek an explanation for particular crime patterns, and part of the explanation may be found in a socioeconomic data layer. Although there are countless possible uses of a GIS by other departments, for purposes of illustrating the analytical power of a GIS, we have selected the Planning Department.

The benefits of analysis can be realized from even a small amount of initial data. The Town of Exeter, for example, has developed a parcel database, which includes a land-use component. These interdependent GIS elements permit Exeter to analyze existing land-use patterns by individual parcel.

Other data layers useful in the planning process include existing zoning districts, with setback requirements and additional constraints; topography; and numerous layers of natural resource data. Many of these are becoming available statewide through the NH GRANIT System (Geographically Referenced Analysis and Information Transfer). (For more information about sources of available data, see Chapter 6)

GIS can be of great use in answering questions about the effects of different plan choices. In order to protect wetlands, for example, several New Hampshire communities have begun to identify and rank wetlands based on standardized criteria. Many of the rankings can be assessed using GIS-based analyses, including size of wetland, proximity to other wetlands, proximity to developed areas, etc. When the rankings are completed, the communities develop a plan showing priorities for wetlands to be protected. In addition, these communities can evaluate the effects of differently sized protective buffers around wetlands and identify the number of property owners who would be affected by the buffers.

As natural resource information is combined with existing zoning information during the master planning process, it is possible to perform a buildout analysis. The objective of a buildout analysis is to assess the extent of land in a community that is developable. Patterns discovered at this stage of the planning process may lead to the encouragement of new development, or they may encourage movement in conservation-oriented directions. Users may pose "what if?" questions, and assess the impact of variations or refinements to the recommendations.

Let us examine the buildout analysis procedure more closely to identify the many GIS operations involved.

A simple query of the zoning layer might produce a shaded map showing the minimum lot size for each district. However, there are usually additional rules limiting the areas in which lots may be built. The first step in a buildout analysis is to identify all areas in a community in which development is prohibited. These may include areas with certain soil types, slopes greater than a certain angle, or areas within a certain distance of a feature.

The user might first select all non-developable land (typically very poorly drained or poorly drained soils) from the soil layer and place the data in a new layer. Soil units with steep slope codes may also be identified and saved in a new data set. (If the GIS has a terrain modeling capability and the necessary topographic data, areas with steep slopes may be derived through other approaches.)

Some areas are considered non-developable based on their proximity to other features. If a community has a shoreland-protection ordinance, planners can use the GIS's buffering capability to identify the strip of land within the limits of the ordinance. In some cases, the buffer strip may vary in width, depending upon the soil type or some other factor. In this case, the user may produce new information by overlaying soil units with the shoreland area to determine exactly where the buffer widths should change.

When all such factors are identified, the user can perform a series of GIS overlays to combine the data from the various layers into a single theme or coverage representing all non-developable land. It is then possible to simplify the information by removing lines in the map that separate adjacent areas with the same attributes. The result is a data layer showing simple, broad areas of allowable development and areas in which development is prohibited or restricted.

A final GIS overlay may then be performed between the non-developable land layer and the original zoning district layer. Instead of a simple map showing building density throughout the zoning district, only developable areas within each district are shaded.

This type of analysis can draw from many useful sources, such as floodplains, aquifers, or any other features explicitly cited in the zoning and subdivision regulations. Publicly owned and other conservation lands and already developed lands can be deleted during the buildout analysis, leaving a map of just remaining developable land.

Summary

Although tax maps are frequently the original data layer that a municipality wishes to see in a computerized format, a fully implemented municipal GIS is capable of much more. Cities, such as Concord, are incorporating cadastral, engineering, political and base map data into a single system. In so doing, they are beginning to notice the cross-department benefits to be achieved with a shareable GIS. While no city or town in New Hampshire currently has all departments linked through a municipal-wide GIS, several are planning to do so.

Finally, the applications listed above must not be thought of as occurring only at the request of municipal employees. The public should have easy access to GIS data, such as through a dedicated computer located in a kiosk or public space. While such an approach has not been implemented in New Hampshire, some communities have started to develop standardized ways of providing information to the public.

Concord, for example, uses the "GIS Request Form", which is shown on the following page. Individuals requesting information simply select the relevant data layers and text fields within each layer, and outline the area of Concord in which they are interested. Applicants may also specify selection criteria, such as those described at the beginning of this chapter.

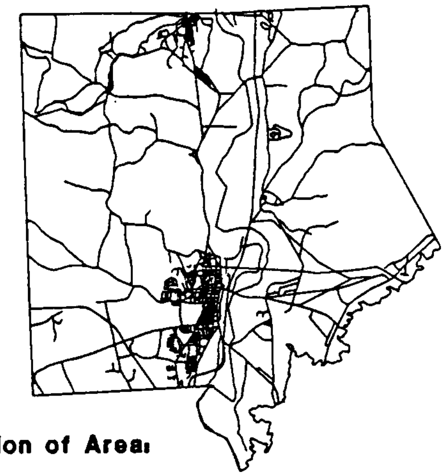
With increased access to a municipality's GIS, members of local government, as well as the public, will begin to find new ways of applying the data. If the use of geographic data leads to more informed decisions, the GIS will be a success.

GIS REQUEST FORM

Data Requested

- ROADS
- PARKING, DRIVEWAYS...
- TRAILS
- WATER BODIES
- SWAMPS
- ROAD CENTER LINES
- BUILDINGS
- MISC (POOLS, CULVERTS, TANKS...)
- PROPERTY LINES
- WARD BOUNDARIES
- ABUTTERS LISTING
- TRAFFIC ACCIDENT INFORMATION
- TRAFFIC COUNTS
- PAVEMENT CONDITION & MANAGMENT
- SNOW, SALT & SAND ROUTES
- CENSUS BLOCKS
- OPEN SPACE PLANNING
- OTHER PLANNING ______________
- CONTOUR LINES (where avail.)
- WATER LINES (where avail.)
- WATER SERVICES (where avail.)
- SEWER LINES (where avail.)
- SEWER SERVICES (where avail.)
- DRAINAGE (where avail.)
- OTHER SERVICES (where avail.)
- OTHER ______________

Outline area of interest



Description of Area:

Text Information

ASSESSOR INFO

- OWNER NAME
- PROPERTY LOCATION
- OWNER ADDRESS
- LAND VALUE
- BUILDING VALUE
- MAP/BLOCK/LOT
- ACCOUNT NUMBER
- CARD
- SCHOOL DISTRICT
- DEED BOOK & PAGE
- SALES DATE
- SALES VALUE
- LAND USE
- LAND USE ZONING
- LAND USE AREA
- TOTAL LAND AREA
- BUILDING STYLE
- BUILDING MODEL
- BUILDING GRADE
- BUILDING STORY
- BUILDING OCCUPANCY
- BUILDING FUEL TYPE
- BUILDING HEATING TYPE
- BUILDING AIR CONDITION
- BUILDING BEDS
- BUILDING BATHS
- BUILDING ROOMS
- YEAR BUILT
- BUILDING AREA

CENSUS INFO

- CENSUS BLOCK
- 1990 POPULATION
- 1990 HOUSING

UTILITIES

- PIPE SIZE
- PIPE MATERIAL
- PIPE AGE

PAVEMENT/ROUTING INFO

- STREET NAME
- FROM POINT
- TO POINT
- LONG CRACKING GRADE
- ALLIGATOR CRACKING GRADE
- PATCHES & POTHOLES
- EDGE CRACKING GRADE
- DRAINAGE GRADE
- ROUGHNESS GRADE
- RUTTING GRADE
- TOWN MAINTAINED
- PAVMENT WIDTH
- ROAD LENGTH
- TRAFFIC VOLUME
- SURFACE CODE
- SHOULDER TYPE
- ROUTE NUMBER
- COST DATA

TRAFFIC COUNTS

- AVG. DAILY TRAFFIC
- AM PEAK
- CODE
- PM PEAK
- CROSS STREET
- STREET NAME
- YEAR OF COUNT

TRAFFIC ACCIDENTS

- STREET NAME
- CROSS STREET
- NUMBER OF ACCIDENTS
- YEAR

OTHER INFO

- STREET NAMES
- TOWN NAMES
- MISC. FEATURE NAMES

GIS USE ONLY **PREPARED BY:** ______

DATE COMPLETED: ________ **TOTAL TIME:** ______

Where Condition

A where condition (from list to left) can be added
Example: Show me all the properties valued greater than $200.000.

____

____

Output Options

- PAPER MAP
- TEXT REPORT
- STATISTICAL REPORT
- MYLAR
- AUTOCAD FILE
- OTHER: ______________

Map Options

- 24 X 36 PAPER
- 36 X 48 PAPER (largest)
- OTHER PAPER SIZE ________
- SCALE ________
- FIT TO PAPER
- DRAFT
- PRESENTATION

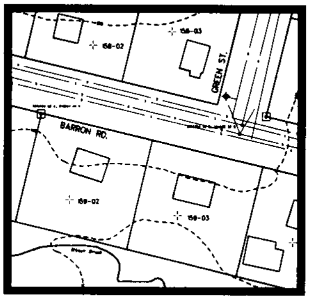
NAME: ______________ **DEPT:** ________

DATE: ________ **DATE NEEDED:** ________

COMMENTS: ______________________________

____

Figure 8. Concord Request Form



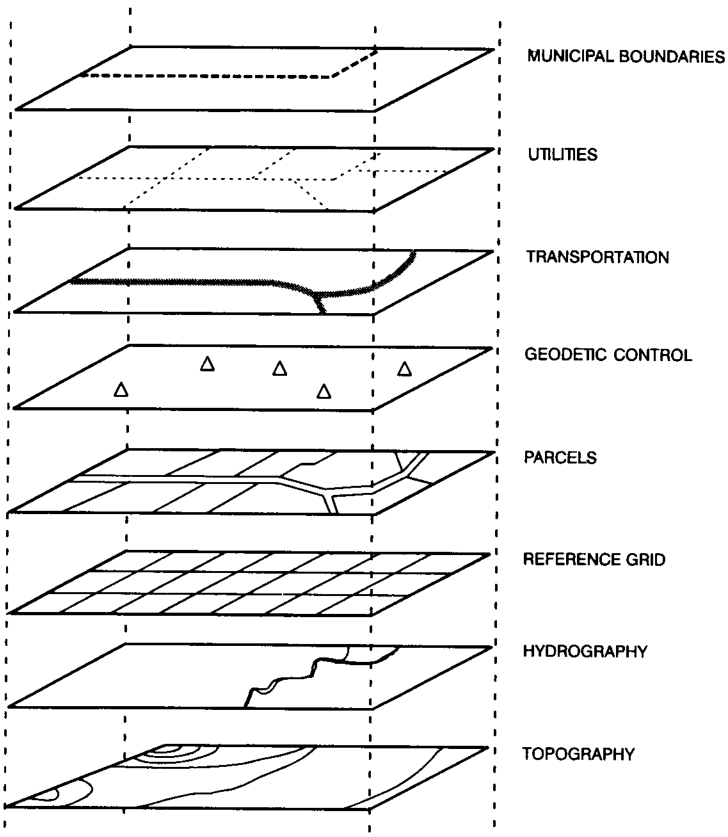
Chapter 2.

What Does a GIS Do, Anyway?

Introduction

A Geographic Information System (GIS) can be an effective tool for helping local officials make sense of the often complex network of individuals, facilities, services, and systems that comprise a municipal government. As explained in the Introduction and in Chapter 1, the benefits of implementing a municipal GIS can be substantial to both the municipality and to the public as the need for information expands.

To appreciate the value of a GIS to local government, one has to understand exactly what a GIS can be designed to do. This chapter describes many basic GIS capabilities.



GIS DATA BASE	
Spatial Data	**Tabular Data**
Municipal Boundaries	• municipality name • accuracy of boundary • date last perambulated
Geodetic Control	• X, Y coordinate • date • agency • method
Transportation	• road name • pavement type • pavement width
Hydrography	• name of water body • type of water body
Topography	• contour elevation

Figure 9. Mapped and Tabular Data

GIS Elements

While GIS packages integrate multiple data formats, they typically manage two principal types of digital (or computerized) data:

- Spatial or Graphic Data. These data often consist of geographic features of interest, such as land parcels, roads and streets, surface waters, and town boundaries. Features may be represented as points, lines, polygons, or grid cells. Groupings of related features, such as soils, often are organized into a single layer within a multi-layered GIS database.
- Tabular, Text or Alphanumeric Data. These data consist of attributes or characteristics of map features. For example, parcel owner names and addresses, pipe diameters, and roadway widths are attributes describing or attached to spatial features. A standard tabular database stores this textual and numerical data.

In a GIS, an explicit linkage is maintained between the graphic data and the tabular data. Usually, the linkage is based on a feature identifier (or ID) that is attached both to the mapped feature and to its attributes.

Topology

There are several fundamental properties that distinguish a true GIS from other digital mapping systems, such as computer-aided drafting (CAD). Principal among these properties is the creation of topology. Topology refers to mathematical expressions that describe the spatial relationships between different geographic features. Put another way, topology offers a method for linking geographic features, such as points, lines, and polygons, in a GIS database.

Three key concepts underlie the notion of topology:

- Connectivity: line segments connect at endpoints or "nodes".
- Area Definition: multiple line segments that connect and completely enclose an area (sometimes called a polygon).

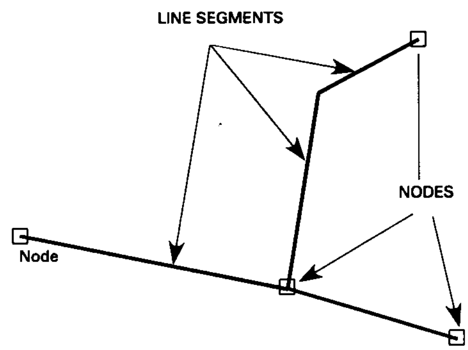


Figure 10. Connectivity

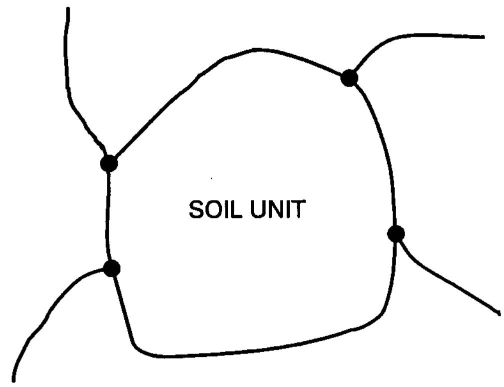


Figure 11. Area / Polygon

- Contiguity: lines have direction and, therefore, have left and right sides. When line segments are stored, the starting and ending points are defined. As one conceptualizes beginning at a starting point and looking towards an ending point, the left and right sides of that line-of-sight are defined.

The ability to generate topology offers several advantages to the user, including greater analytic capability and greater efficiency. As topology is built into the spatial database, geographic intelligence is created. With this new information, the user can now pose an array of analytical questions. For example, a topologically defined database can answer such questions as: "What is the most efficient design for a city bus route?" (requiring connectivity); or, "Where are there land uses that are inconsistent with city zoning boundaries?" (requiring area definition); or, "What parcels of land are located next to the city park?" (requiring contiguity).

Topology also affords the user a number of less apparent, but equally important, advantages related to efficiency. Because of the three basic concepts described above, each line segment "knows" what is on its left and right sides, which allows each segment to be stored only once. Consequently, using a GIS database to manage geographic data requires fewer data storage resources, reduces the cost of data maintenance, eliminates data redundancies, and increases processing speed.

The remainder of this chapter focuses on the types of spatial tools, operations and analyses available within most GIS packages. While the set of tools available will vary from one GIS to another, it is possible to define a typical set of capabilities available in most standard packages. Collectively, these capabilities distinguish GIS software from other types of computer mapping packages available today. The tools are presented under five general headings:

- Data Management/Coordinate Manipulation Utilities
- Spatial Retrieval, Measurement, Query
- Spatial Analysis
- Network Functions/Terrain Modeling
- Output Production

Although these categories are not mutually exclusive, this organization may prove useful to the reader. Also, this list is not meant to be exhaustive, but should provide the reader with an appreciation of the wide range of tools available.

Data Management/Coordinate Manipulation Utilities

A suite of data management tools is available to facilitate the development, implementation and maintenance of GIS databases. The process of developing GIS data requires, in part, access to coordinate manipulation utilities, allowing a user to standardize the map coordinate reference system in the database. The coordinate standardization may be required to co-register data between multiple data layers, such as roads and parcels, or between multiple contiguous tiles (or map sheets) in a single map layer. Because databases must often integrate data from different sources, these coordinate-based tools are critical to the effective development of a database.

Coordinate Transformation. This process converts data from one coordinate system to another through some combination of data translation, rotation or scaling. It is often applied to data that are digitized, and enables the user to convert the resulting raw data into data with a real-world coordinate base.

Map Projection. Map projections have been developed to allow the representation of the earth's 3-dimensional surface as a flat, 2-dimensional map. GIS software packages maintain a library of programs that describe each of these mathematical relationships, and permit the user to convert data from one projection to another, as for example, from a Mercator projection to an Albers projection. This process is frequently required as new data, from outside sources, are introduced into a GIS database. Beyond the strict data integration considerations, users may apply these tools because a given map projection yields results that are more appropriate for some applications and less appropriate for others.

Map Edgematching. Edgematching describes a set of editing tools that allow users to spatially align features meeting at map manuscript, or map sheet, borders. The process is often required to fix errors -- those that existed on the source maps or those that were introduced in

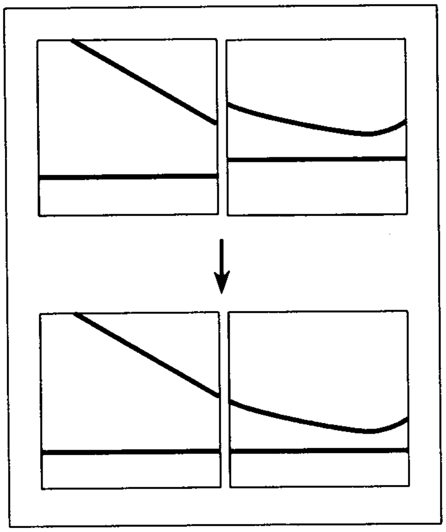


Figure 12. Edgematching

data automation. Edgematching is performed after the individual map sheers are transformed or projected to a common coordinate base, and prior to digitally joining adjacent map sheets. (See Figure 12)

Feature Generalization. This set of tools enables the user to simplify or generalize lines or polygons. One standard generalization tool is that of line coordinate thinning, where the user removes excess points from a line representation.

Feature Densifying. The opposite of generalization, feature densifying is used to add shape points along a line segment. The shape of the original line remains constant through the densification.

Mapjoining. When a map covering a large geographic area is required, users may need to digitally join or "sew together" adjacent maps covering smaller geographic areas. The mapjoining step is often followed by a process whereby the resulting map seam(s) is removed (see Figure 13).

Spatial Retrieval/ Measurement/Query

Once a user has created a GIS database, the following tools are available to query the database and retrieve data:

Spatial and Attribute Queries. The user may want to retrieve data with specific spatial characteristics or patterns. The basic spatial query is to ask what exists at a certain location. For example, a user with a graphic display may want to point to a screen position and determine what feature occurs at that location. This type of query is based on the graphics data.

A second type of query is performed based on the feature attribute data. In this instance, the user may ask for a display (or listing) of all locations at which a specific attribute exists. For example, the user may query the database to identify a certain set of features, such as parcels of a certain minimum size.

Windowing. The windowing capability allows the user to visually "zoom in" or "zoom out" at a given location. The operation enables the user to view a subset of the database at a scale larger or smaller than the original display. Windowing is a viewing tool only, and no data are generated by this operation.

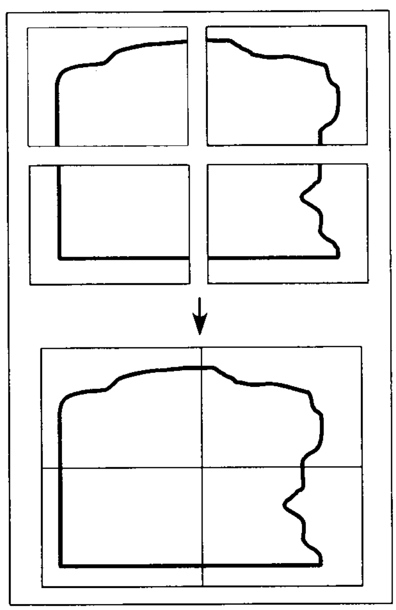


Figure 13. Mapjoining

Spatial Measurement. GIS users frequently need to perform simple measurements on the data. GIS tools are used to measure feature lengths, perimeters, areas, and distances between features.

Statistical Tools. Basic statistical analysis of data, such as mean values, value ranges, standard deviations, and frequency tables, can be performed with most geographic information systems.

Spatial Analysis

Spatial analysis is a group of analytical techniques or tools for studying the location and spatial dimensions of geographic entities, and for investigating the relationship among sets of geographic entities. The tools for spatial analysis are a distinguishing feature of geographic information systems, and are available because of the topological nature of the database. These tools enable users to develop models that identify and describe real-world spatial relationships. Several of these analytical tools are described below.

Buffering. Buffer generation is one of the frequently applied analytical tools included in GIS packages. This tool is used for proximity analysis, a technique used to determine the spatial relationship between a selected feature and its neighbors. A buffer zone identifies the geographic area around a particular feature, and is generated based on some user-specified width.

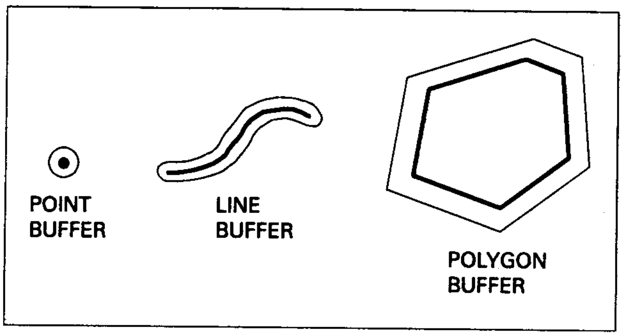


Figure 14. Buffering

Clipping. Frequently called "cookie cutting", the clipping operation is a type of digital "windowing" that allows a user to extract from a particular data layer a set of features falling within a defined boundary. With the clipping function, the user is generating a new data subset that, subsequently, may become the unit of analysis for further operations.

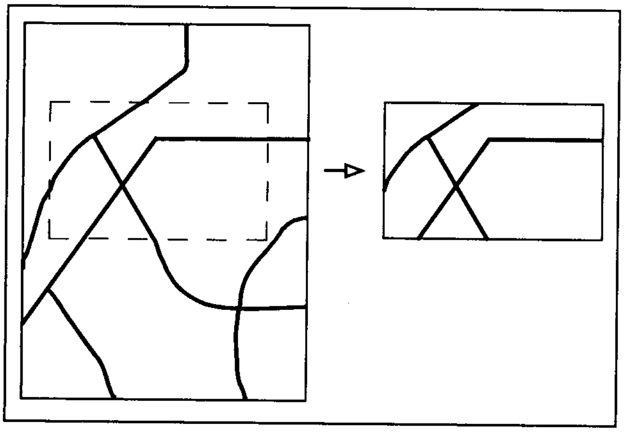


Figure 15. Clipping

Dissolve. The dissolve operation allows a user to remove boundaries between adjacent polygons with the same code. It is often used to simplify a complex data set. For example, if the required data are entered into the GIS database, it is possible to digitally produce county boundaries from a data set of town boundaries.

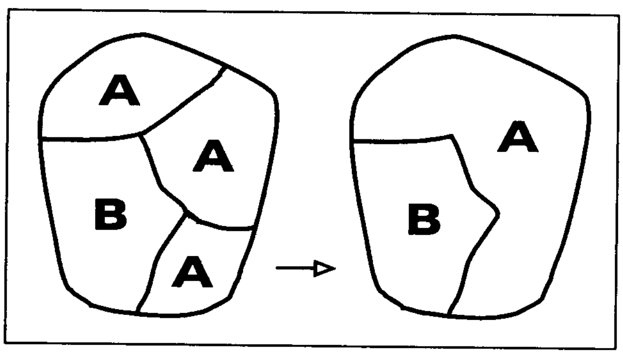


Figure 16. Dissolving Interior Boundaries

Overlays. These tools overlay one data layer onto a second layer to produce a third, composite coverage or layer. The composite coverage retains the spatial and attribute information from the two layers from which it is constructed.

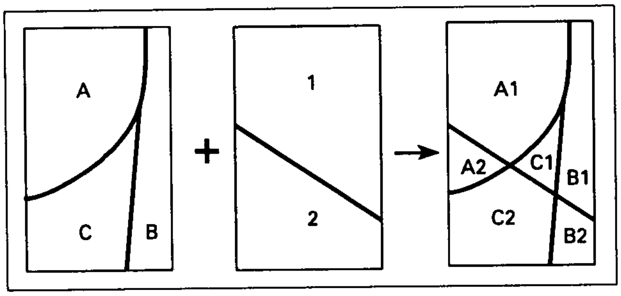


Figure 17. Map Overlaying

There may be a number of options available to create the composite coverage, including a "union" in which all features from two polygonal data sets are captured, an "intersection" in which only the features common to both polygonal sets are captured in the output, or a "line-in-polygon overlay" in which the arcs of one coverage are overlaid on a second polygon coverage and the relevant polygon attributes are transferred to the arcs.

Network Functions/ Terrain Modeling

A variety of tools are included under this functional heading. Network tools allow a user to analyze the connectivity between a set of geographic features. Terrain analysis refers to a set of tools that allow a user to process, analyze, and represent a data surface.

Networking Tools. A digital network describes a connected set of lines (or arcs), and is commonly used to represent road centerlines, surface waters, or facilities. Network tools are used to analyze the relationships or connectivity between locations on a network, such as the calculation of optimal routes through road systems or the best location of power lines along a grid. Figure 18 shows the resulting optimal route for picking up senior citizens at the six locations indicated on the road map.

Figure 18. Network: Optimal Route Calculation

Terrain Modeling Tools. This set of utilities allows the user to model and analyze a 3-dimensional surface, such as the earth's, where the surface represents a set of continuous data. One typical application of these tools is for processing and displaying terrain elevation, slope, line-of-sight, and surface texture data.

Output Production

Standard GIS software packages provide a wide array of tools for creating output in tabular form, mapped form or digital files.

Standard Reporting. GIS software include tools for generating output in standard tabular (text or alpha-numeric) format. Users may issue conventional database queries and produce customized tables and reports.

Map Production. The ability to generate map (or graphic) output is common to all GIS software packages. Most provide a variety of options for selecting the appropriate output scale, symbology (i.e., text fonts, line colors, etc.), and format. The output may be directed to different output devices to produce slides, viewgraphs, and paper copies. A typical constraint in the map production process is the availability and capacity of plotting and printing devices.

Digital Output. Typically, there are several options for converting or translating data into formats readable by other software packages. Similarly, GIS packages provide tools that permit the user to import data from other systems. These capabilities allow users to share data generated by other organizations, such as the U.S. Census Bureau, the State of New Hampshire, counties, or other municipalities.

Summary

A geographic information system can offer a municipality a wide range of tools and analytical capabilities, both to improve existing services and to expand on the range of services it can provide. These tools can assist in the development and maintenance of the database, in the manipulation, analysis and visualization of the data, and in the generation of products from the database. It is important for users to understand the breadth of functionality available to ensure the full utilization of the municipal GIS.

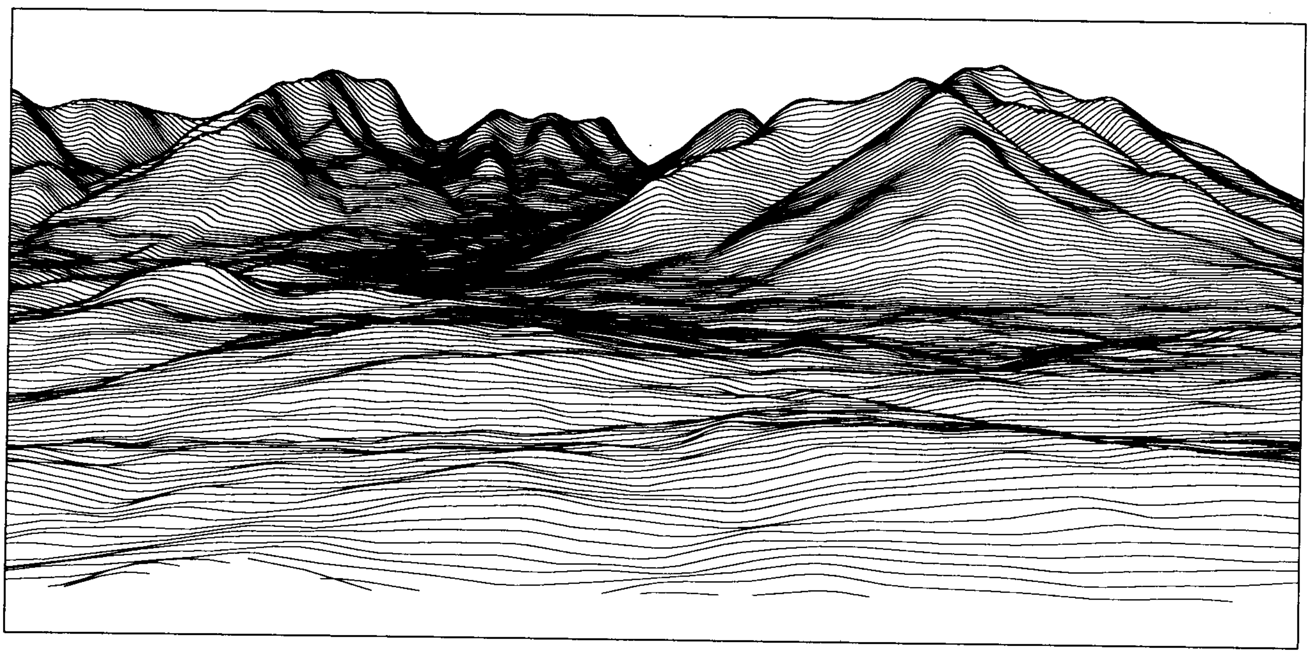
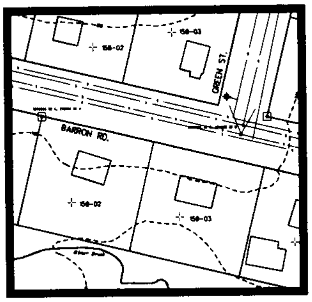


Figure 19. Terrain Model



Chapter 3.

Implementation Plan and Strategies

Introduction

It is easy to become overwhelmed by the technical jargon and issues involved in establishing a municipal GIS. One assumes the worst is over after learning about "attributes", "digital data", "tabular databases", and "spatial analysis". Actually, this was the easy part. Now the hard work begins!

At this point -- the planning stage -- one must come to grips with many of the difficult and complex issues, such as securing political support and funding, identifying requirements, selecting an appropriate system, and convincing staff to use the GIS once it is operational.

Clearly, one needs an implementation plan and a strategy for achieving the plan to the optimal extent possible. Without careful attention to these, a municipality could end up buying the proverbial white elephant or the Brooklyn Bridge. The intent of this chapter is to present the elements of a well-defined plan and to offer suggestions on strategies to help municipal officials avoid potentially costly mistakes. While the process for full implementation is presented, it can be modified to fit specific needs.

Implementation Plan

A geographic information system does not spring full grown from the head of some technical genius or vendor. Like all complex computer systems, a GIS should be implemented according to a specific process. Typically, this process involves four phases, which are described briefly as follows:

Concept Phase. Activities during this initial phase are critical because they will result in a set of clearly defined user needs or requirements, which will form the basis for the system design. The user needs may be identified through a formal interviewing mechanism (i.e., User Needs Assessment), through a committee discussion mechanism (i.e., Information Management Committee), through a carefully crafted questionnaire, or through some combination of the three. In all three instances, the assessment is conducted to identify and define the needs of current and potential system users. The assessment is followed by an evaluation of the information collected, and a cost-benefit analysis is performed.

The latter activity involves answering one question: "Given the results of the needs assessment, do the long-term benefits justify the implementation and on-going operational costs of a GIS?" If the benefits outweigh the cost, then the process proceeds to the GIS design phase.

Design Phase. This phase involves an analysis of current system capabilities to determine the types of data generated and used. The current system might be manual, automated, or some combination. The objective during this phase is to detail both the contents of the data elements used or produced, including specific map sets and associated tabular data, and the format, media, accuracy and symbolic representations of those data elements. The information gathered will serve as the baseline for the design of the database, software, hardware, applications, and staff requirements.

Typically, a detailed implementation plan is created in this phase and a pilot project is conducted to test the feasibility of the proposed GIS. If the pilot project results prove out the proposed system and database design, then one proceeds to the next phase. Table 1 suggests a possible approach for implementing a municipal GIS program.

Development Phase. The development phase focuses on the implementation of the GIS, including acquiring the system, defining staffing and training requirements, preparing operation procedures, and preparing the GIS site. In addition, certain primary data elements may be collected, catalogued and prepared for use by the GIS staff, including survey information and aerial photographs, and base maps.

Operational and Technical Support Phase. This phase involves the installation of the GIS, including data conversion, applications development, and overall conversion of the existing system to automated operation. If a municipality contracts for the production of digital base map data, the agreement should indicate that ownership of the digital data rests with the town or city. Once installed and operational, the system is reviewed and expanded, as appropriate.

After the GIS is fully operational, on-going technical support will be required. Typically, support includes training, updating software and hardware, data, and resolving technical problems.

Strategies to Consider

Several key activities of the four-step process are described in more detail in the following subsections because we believe that understanding them is essential to successful GIS implementation.

User Needs Assessment

To be effective, every planning process requires comprehensive vision and participation by end-users. A common means to satisfy both criteria is a "user needs assessment", sometimes referred to as a "user requirements analysis". These surveys can be complex, requiring the use of multi-page questionnaires, or they can be simple, requiring answers to just a few questions. For most municipalities, the latter approach may prove most effective. For reference, a sample user needs assessment questionnaire is included in Appendix 7 of this guidebook.

The assumptions underlying the complex survey are that municipalities already maintain detailed file inventories and employ staff familiar with GIS applications. If the municipality has a manual-automated system in place and wishes to convert fully to an automated GIS, then this approach might be appropriate.

For municipalities planning to convert a manual to a fully automated system, the simple survey is most appropriate. This approach requires answers to several essential questions that presume little to no knowledge of GIS technology by municipal staff. The questions include:

- What responsibilities does each department have?
- What map and text data are collected and maintained by each department?
- How much time is spent in maintaining and updating the information?
- How is this information used and analyzed to support decision making?
- What geographic identifiers are used, such as address, map/lot number?
- What map scales are used?
- What software and hardware, if any, are used?
- What existing activities could be automated?

Table 1. Sample Implementation Strategy			
SYSTEM FEATURES	**1-2 YEARS**	**3-5 YEARS**	**5-10 YEARS**
System Design	Conduct User Needs Assessment System Design and Development	Operational Phase	Continuing GIS Operation Technical Support
Personnel	Form GIS Committee Hire Technician	Hire GIS Coordinator-Manager	Hire or Contract for Services for Advanced Applications
Hardware	PC's in Planning and Assessor's Office Planning and Assessor Share Digitizer, Plotter and Back-Up Device	Install PC's in Public Works/Engineering, Conservation and Building Inspector Link PC's Together Through a Local Area Network	*Option 1:* Additional PC Station to Town Clerk, et al *Option 2:* Purchase UNIX Workstation with Terminals in various Departments to Perform GIS Functions
Software	dBase IV, FoxBase, etc. PC ARC/INFO, ArcCad	Additional copies of PC ARC/INFO, as necessary PC ArcView 2	*Option 1:* Additional copies of ArcView 2 *Option 2:* ORACLE or other DBMS for mini workstation, ARC/INFO and ArcView 2
Data Development	*Map Layers:* * Ground Control * Base Map - Roads, Hydro, Parcels, Zoning Districts *DBMS Files:* * Assessor Files * Site Plan Inspections	*Map Layers:* * Topography * Utilities * Floodplains * Wetlands	Map Layers: * Updating of Map Layers as needed
Existing Data	*GRANIT Database:* * Municipal Boundaries, Transportation, Land cover/Land use, Soils, etc.		

The needs assessment must clearly define the use of a GIS by current and potential users, and produce a definitive statement of end- product characteristics, production rates, data volumes, and cost-benefit rationales.

While the initial needs assessment is critical for the planning phase, it can be a serious error to rely solely on those results as the GIS becomes operational. The result might be a limited system which cannot be expanded to meet future demands. Do not assume that the complexity of a GIS will forever limit its use to the engineering or information services section. Staff training, increasing computer literacy of younger employees, more powerful and "user friendly" software and declining hardware costs with increasing performance guarantee an ever-expanding demand for GIS applications. It is recommended that each municipality develop a customized questionnaire that can be executed on an on-going, cyclical basis, to ensure that the GIS continues to meet the needs of its growing clientele.

Information Management Committee

A second approach to determining a municipality's GIS needs is to establish a citizens information management committee. Although every municipality is different in character, population, financial resources and staff, planning for a GIS does not require re-inventing the wheel. First, there are certain basic functions common to all local governments. The brief outline of municipal functions listed in Chapter 1 illustrates the variety of ways in which a GIS could help a community now, or in the future.

After identifying these functions, the committee could analyze how each function might be made more productive through the use of computer mapping and database integration. Creating a municipal information management committee can be quite helpful for this task. In many instances, a citizens committee of interested and knowledgeable residents could work with key municipal staff to investigate the implementation of a municipal GIS. Committee members should possess a variety of expertise and represent different types of services provided by the community.

Once again, do not assume that GIS technology has limited applicability. As the community grows, every department will find a need for a GIS.

Pilot Study

Planning and conducting a pilot study or project is fairly common in the implementation of a GIS. It affords an opportunity to test all phases of the system, including data collection, database design and development, data automation, data analysis, manipulation and query, and data output, in a controlled environment. The pilot study usually involves selecting a small area of a municipality, developing a complete data set, conducting a range of analyses, and generating sample products.

The City of Dover, for example, conducted a successful pilot study to assess the benefits and advantages of a GIS for this community of about 26,000. The pilot area, which was selected by the City Planner and City Engineer, was a 6,000-acre, 270-parcel area that incorporated both rural and urban characteristics. Manmade and natural features were included as graphic layers. Attribute (text) data, such as property data from tax records and infrastructure files, were collected and added to the elements of each layer.

The results of the study added significantly to the argument that small municipalities can benefit from a GIS. For example, Dover and its consultant concluded the following:

- Data storage redundancies were minimized
- Updating data was standardized and more efficient
- Information retrieval efficiency, as compared with manual methods, was increased
- Common access to up-to-date data by several departments was established
- Maps and charts can be produced quickly for a variety of applications and requests

(Source: Jack Lee, Land Systems, Inc.).

In many cases, a specific project or application generates the initial funding for the municipal GIS. For example, the impetus for some systems has been property revaluations, construction of a new sewer interceptor, or demand for more efficient emergency response by fire and police units. In such instances, the system tends to be too narrowly designed to meet only that project's particular requirements. By defining a small geographic area and preparing accurate base mapping, including recent photography, elevation contours, building locations, utilities, etc., the staff will have a hands-on opportunity to explore data needs and applications over a wider range of municipal activities.

Conducting a pilot project may also benefit the community by limiting its financial exposure. As staff see products emerge from the study, they will begin to appreciate how the system can be used to meet their own needs and the needs of their departments.

Other Key Considerations

Cost-Benefit Justification

To implement an affordable GIS, local decision-makers must understand the immediate costs of designing, developing, installing and maintaining a GIS. These costs include:

- User needs assessment and feasibility evaluation
- Database design/development, and/or acquisition
- Computer software/hardware acquisition
- Data conversion
- Applications development
- Pilot study
- Staffing and staff training
- System operation and maintenance
- Hardware repair, replacement, and upgrading/expansion
- Technical support

To justify proceeding with a GIS, a cost-benefit analysis must be conducted. This analysis should yield a list of long-term benefits, such as cost savings resulting from the elimination of redundant, inefficient efforts and the timely availability of information to local decision-makers, and a list of the costs of installing and operating a GIS and the associated long-term costs. If the benefits outweigh the costs, then implementing a GIS might be feasible.

Studies of cost-benefit ratios range from 1:2 to 1:4, calculated for a period of 10-15 years. In one study, a 1:2 ratio assumed a 20 percent reduction in planning and engineering personnel for producing and updating maps. A 1:4 ratio represented the presence of a common information system with costs shared by local government and utility partners.

(Source: The Local Government Guide to Geographic Information Systems: Planning and Implementation, *page 11)*

Cooperative Ventures and Available Information.

Once a municipality has identified functional needs and geographic information requirements, an effort should be made to use available data and to share development costs with other organizations. One source of digital spatial data is New Hampshire's GRANIT System 1:24,000 scale data, which are appropriate for master planning and other generalized community studies. The NH GRANIT System database includes roads, soils, railroads, surface water, aquifers, wetlands, land use/land cover, and other features. Chapter 6 contains useful information on available data.

Another possibility for cost sharing is to arrange a public-private financial partnership. Utility companies or local surveying or engineering firms are likely prospects. A utility company whose franchise area includes part or all of your community may have aerial photography and large-scale digital base map data. As a word of caution, however, every financial partnership should include a written contract specifying who owns the data, software and mapping products.

Records Management

More and more, local governments are using computers to support a variety of municipal functions. For example, finance departments are using spreadsheet programs, while assessors are using programs to keep track of property owners, land values, and building improvements. As individual users, they give little thought to the long-term goal of organizing, storing and sharing information with other departments. This lack of a records management plan often forces departments to backtrack and restructure their initial computer files when a GIS is about to be implemented.

One approach to developing a municipal GIS is to focus on the municipality's existing tabular data. Key questions that can be asked are:

- "Does each department store its records in a unique filing system?"
- "How long does it take to locate all the documents related to a particular property, such as zoning variances, subdivision approvals, road construction bonds, current tax assessments, and building permits?"
- "Are there piles of yellowing, rolled blueprints and stacked boxes of paper files collecting dust in the basement of the town hall?"

If the answer to these questions is "Yes", then your municipality needs a Records Management Plan. By exploiting the power of database management to build common geographic identifiers, such as tax map and lot number, and address, into different municipal data files, it is possible to conduct certain analyses efficiently and cost effectively. Also, this approach lays the foundation for the subsequent addition of a GIS component.

Many of the principles involved in an automated records management system are discussed in Chapter 5 in connection with tabular databases.

The implementation process described above is typical and feasible for municipalities considering or planning a GIS. However, the key to successful implementation is making the GIS an integral part of a total information management system to serve the decision-making needs of local officials. It also requires careful attention to several issues, which are discussed in the remaining portion of this chapter.

Winning Political Support

Make sure to maintain realistic expectations. When presenting the benefits of a GIS to a municipality, one must be careful about promising more than the technology can deliver. Ideally, a GIS will be perceived as a crucial element of a broader municipal information management system that improves data analysis for decision-making and delivery of public services. When considered alone, GIS is not a total solution to the information issue and, without trained personnel to take advantage of the system, it might be perceived as a costly luxury.

Find a Champion

Getting a GIS project underway requires enthusiastic dedication during the often frustrating implementation process. Sporadic annual appropriations or administrators' reluctance to commit time and personnel can easily turn a fledgling GIS project into just another dust-gatherer. In order to ensure on-going funding and staffing support, at least one influential decision-maker should be enlisted as the "champion" or "crusader" for the project.

Designate an In-House Coordinator

Today's tight municipal budgets usually cannot support daily assistance from a private GIS consultant. Identifying one employee who understands software and hardware functions, and is capable of overseeing and coordinating GIS implementation, is one approach to consider. In communities with more than a handful of full-time employees, it may be desirable to appoint a committee to coordinate the project. Promising candidates for a committee are the library director, town planner, assessor, finance director, emergency services dispatcher, and public works director.

Products for Decision Making

After appropriating substantial sums of money for a GIS, local officials will be eager to see results. Products that assist selectpersons or town councilors in making policy decisions can be the key to securing their continuing political and financial support. When planning the implementation strategy, remember to identify and schedule periodic delivery of products for elected officials to use. Examples of these products could include:

- town roads requiring improvements during the next five years;
- areas of the community where many individual septic systems are failing; and the
- location of commercial and industrial developments approved during the past year with a schedule of anticipated property tax revenues.

Securing Financial Commitment

With the introduction of lower cost, more powerful hardware and easier-to-use software, the chances for successful GIS implementation are improving significantly. For example, New Hampshire municipalities with GIS capabilities report that the cost of preparing a complete digital base map and parcel information ranges from $25 to $35 per parcel.

A sample implementation strategy for GIS hardware and software appears on page 25.

Generating New Revenues

A fully integrated municipal GIS can provide information products for government officials and local private sector organizations. The potential for marketing GIS-derived products as a new source of revenue should not be overlooked. In addition to providing abutter lists quickly, GIS is well-suited for creating complex analyses for real estate agents, land developers, lending institutions, and utility companies.

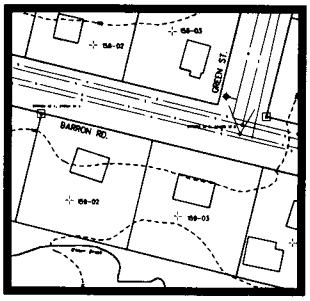
In 1994, the General Court enacted a law (RSA 31:95-f and 47:11-c) which enables New Hampshire communities to establish geographic information systems and to control the distribution of the information. Furthermore, both towns and cities may finance the completion and perpetuation of these systems through special revenue funds or through not-for-profit corporations. The law also allows municipalities to charge fees for the use of these systems. A copy of this law is included in Appendix 9.

Summary

Throughout this chapter, we have stressed the importance of carefully planning the implementation of a municipal GIS. Fundamental to the planning is the recognition of a four-phase process to guide the implementation from concept to operation. Using this process ensures that:

- the municipality identifies its objectives for the GIS;
- the system's potential users provide input on their needs;
- a pilot study is conducted to test out the proposed design; and
- the plan is supported by strategies throughout the GIS implementation process.

In addition, we have suggested means by which a municipality may secure financial and political support, and generate revenue from the sale of GIS-derived products.



Chapter 4.

Choosing the Right Stuff – Software and Hardware

Introduction

There are several important components of a GIS, and each component must be selected to fulfill the municipality's geographic information needs and to function harmoniously with the other components. At a minimum, a system's components include:

- Software
- Hardware
- Tabular data
- Trained staff

Many of the decisions involved in selecting a GIS can be simplified by first creating a plan for integrating this technology within the local government. This chapter explores a set of logical steps for selecting an information system. Before moving on to the discussion, however, it is worth reminding the reader of the functions a GIS performs.

Whether a system is completely manual, completely automated, or a combination of both, it will maintain five primary functions:

1) acquisition of data and its insertion into the data base,
2) maintenance of and retrieval from the data base,
3) analysis of data retrieved from the data base,
4) monitoring of the system, and
5) interaction between the user and the data base.

(Source: U.S. Department of the Interior, Fish and Wildlife Service, "A General Design Schema for an Operational Geographic Information System", June 1977).

Software

Selecting software needed to assemble a GIS for a municipality depends, to a great extent, on the uses identified by the needs assessment and the budget. However, bear in mind that the system near-term uses and benefits will change once system users begin to understand the efficiencies gained in planning, analysis, and routine report preparation for different departments and the public.

Software should be selected with an eye to the future expansion of the system and compatibility with other local, state, and federal government geographic information systems. Buying a system that can be expanded as needs grow will result in cost savings.

Software Components

In general, a GIS consists of three basic software components:

- Graphical software generates graphic display on a video screen and produces map output on a plotter.
- Database management software (DBMS) is used to store and manipulate tabular data, such as parcel-based data on tax lot numbers, zoning district classifications, and other geographic features within a municipality.
- Spatial analysis software supports the kinds of functions described in Chapter 2 of this guide book.

There are two types of database management software: flat file or linear and relational. While the former stores data in one or a few large files, the latter stores data in "tables" linked by a "key field". Flat file programs are easy to use, but as the data grow in size, this type of file can become unwieldy and slow in processing complex queries. Relational data base programs, on the other hand, process queries faster because individual table size is small and, when queried, they search only the tables containing the data requested. The relational database is recommended for a municipal GIS because of the large amount of data being managed.

Other Software Components

In addition to the three basic components, other programs might be necessary for an effective GIS, including the following:

- Network software is required if the plan is to connect all departments through a computer network using a file server. Network software selection will depend upon the specific types of hardware and other software to be used. Regardless of which software you select, all the major programs are becoming more powerful with each revision, as well as more reliable and easy to use once set up properly. If a network is being considered, then it is critical to contact a reputable vendor and a consultant who specialize in networks, as implementing a computer network is not a task for the casual computer user.
- Desktop mapping software can be used to ask questions of the GIS and produce printed reports, screen plots of thematic maps or hardcopy output. These programs are easy to learn and use, and less expensive than the full GIS applica tion. However, they lack many features to manage the data in a GIS and rely on simpler analyses, which may be less precise and accurate than a full GIS management program. If you choose to use these, bear in mind their limitations.

Hardware

With all the technical jargon and rapidly changing technology in hardware alone, it is important to be acquainted with the basic hardware terms and the capabilities of peripheral devices, such as digitizers, plotters, printers, scanners, and the like. Selecting a reputable dealer to recommend specific brand names and models is critical at this stage. It is also important to select a system that can be expanded in the future.

Choosing a Hardware Platform

One of the most hotly contested topics among consumers is which hardware platform is the best. As with many similar topics, the definitive answer is always: It depends on your application. In general, the majority of users to whom this guidebook is targeted will find the PC platform (i.e., IBM PC or IBM PC compatibles) to be the most popular choice. PCs are relatively inexpensive to purchase and maintain, and most GIS application software, such as AutoCad, ArcCAD and Geo/SQL, is readily available for them. This statement is not intended to discredit the more powerful workstation or Apple Macintosh computers, as they have advantages over PCs in certain situations.

Operating systems must also be considered carefully. This is software that controls the computer's basic functions, such as allocating memory and loading/executing programs, and allows users access to storage devices and input/output devices. The names may sound foreign or familiar -- MS-DOS, MS-Windows, OS/2, UNIX, Apple System 7 and so on. In the PC environment, the choices are few, either MS-DOS or OS/2. Most PCs will also include MS-Windows in the package, and there are many applications available, including the popular GIS products, that take advantage of the MS-DOS/Windows graphical interface and ease of use.

Microsoft (publisher of MS-DOS and Windows) has recently upgraded its Windows product with Windows NT, which is more powerful and complex than Windows 3.1. The advantages of the Windows NT include a full 32-bit application for high-speed operation, built-in networking, and peripheral management tools.

Currently, there are few applications that take advantage of these features, but this is likely to change as the market embraces this system. Autodesk, for example, has targeted Windows NT for future releases of AutoCAD. Be aware that Windows NT has extensive hardware requirements -- and added costs -- which should be considered before proceeding in this direction.

General PC Recommendations

Assuming that the majority of readers are considering a PC-based system, it is appropriate to discuss several general considerations for selecting a system. GIS can be a very computationally intensive application, both in storage requirements and day-to-day operations. Therefore, it is imperative to purchase a system that is both powerful and reliable. Pentium-based systems, for example, are now available from several computer manufacturers, but the reliability of these systems is questionable due to heat and compatibility issues. These issues will likely be resolved shortly.

While the PC industry abounds in buzzwords, it is surprising the impacts some seemingly minor items can have on system performance. Options like local bus video, cache memory and SVGA video monitors individually cause incremental increases in performance, while not substantially increasing the total cost of the system. Selecting a hardware chassis (or case) that provides ample room for expansion will incur only a small cost increase, but usually is well worth the expense when upgrading is necessary.

Due to the rapid change in computer technology, it is not possible to discuss in detail which options are most important when purchasing a computer system, as doing so would date this publication. Again, it is important to work with a reputable dealer who can be trusted to recommend appropriate hardware. Of particular importance when purchasing a system is to write well-defined hardware specifications, especially when preparing bid documents.

Peripherals

The term peripherals refers to all the equipment attached to a computer that is used to generate or record data, store data, or to produce output in hardcopy form. These devices include, but are not limited to, digitizers, mice, printers, plotters, scanners, and CD-ROM drives. This section discusses peripherals in general.

Digitizers are flat devices, such as tables, used for converting to digital form (hence digitizer) the line and point features found on paper maps or drawings. These devices range in size and complexity from 9" x 9" with a single stylus-type pointer up to 48" x 60" with multiple- button cursors (called a "puck") and backlit surfaces. Once very expensive, their costs have dropped recently due to the increased use of alternative conversion methods with

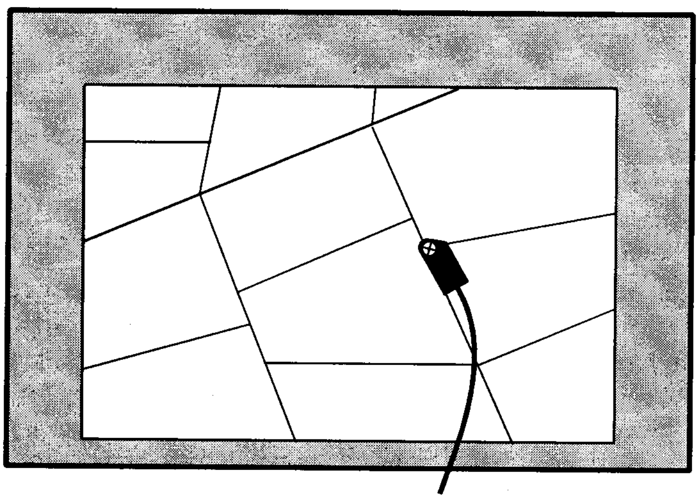


Figure 20. Digitizing Table and Puck

scanners and automated or interactive vectorization products.

Mice are simple pointing devices used to interface with a GIS or CAD system, or with any program employing a graphical interface, such as Windows. While they can be used to draw and edit CAD drawings, they cannot digitize. Most PCs include a mouse as standard equipment. Variations of this device are trackballs and joysticks.

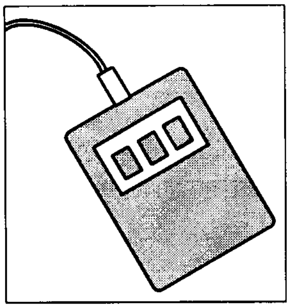


Figure 21. Mouse

Printers fall into several distinct categories: dot matrix, laser, inkjet, and thermal. While the dot matrix models are inexpensive to buy and operate, they are noisy and produce low quality output compared with laser and inkjet printers. The choice between laser and inkjet is more one of economics and speed, unless color output is desired. Typically, laser printers are faster and the quality of output very high. Realistically, thermal printers are applicable only for high-quality color printing, as they are slow and expensive.

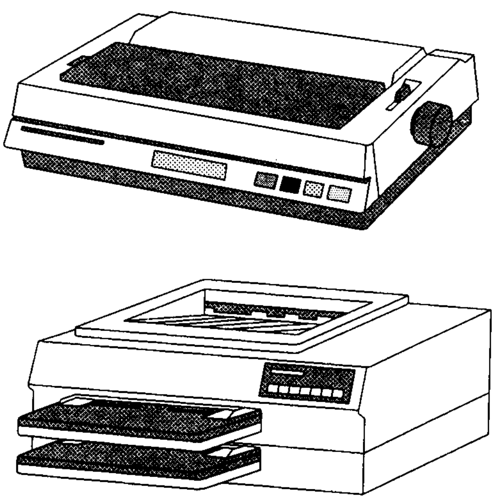


Figure 22. Array of Printers

Plotters are used to produce large-format (larger than $8\frac{1}{2}$" x 11") paper maps and drawings. There are several categories of plotters: pen, thermal, inkjet, and electrostatic. Although pen plotters remain popular, they are being replaced by thermal and inkjet plotters, which use a different technology. Instead of drawing lines with pens, thermal, inkjet and electrostatic plotters create an image with a series of dots. Thus, these devices are termed raster devices. Thermal plotters are very fast, but have a higher initial cost than inkjets. Also, the media used is expensive and, generally, is not of archival quality. Inkjets can plot on a variety of standard media with high-image quality, but at about half the speed of thermal and electrostatic plotters.

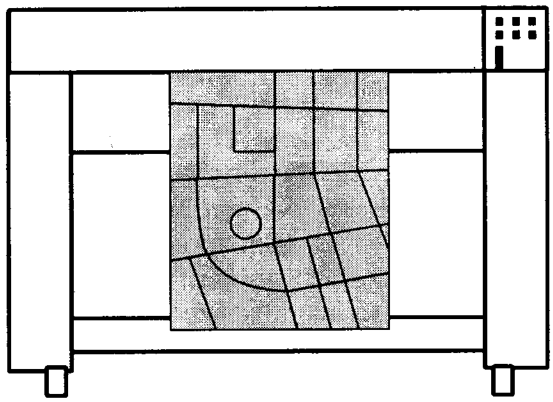


Figure 23. Plotter

Lastly, electrostatic plotters use a process similar to photocopying machines to deposit a liquid toner on a special paper. They are very expensive, but can produce hundreds of high-quality plots daily, virtually unattended.

A word of caution: When selecting a plotter, be sure to consult your local Registry of Deeds as to what medium is acceptable for recording purposes. Some will accept permanent ink on original mylar (as only a pen plotter can do), while others will allow other imaging methods and media.

Scanners are optical devices that recognize dark and light dots on a flat surface and convert them into a digital file, but with some additional computer-aided manipulation and manual editing. These devices range in size from simple hand-held models to full width (36" wide) scanners capable of scanning a 36" x 48" drawing.

Using scanners to convert existing paper maps and engineering drawings to digital format is a popular and useful method. However, if the number of maps to be converted is limited, then a more cost-effective approach is to have exist ing drawings scanned by a reputable firm and then buy only the conversion software to vectorize the scanned images provided by the vendor.

CD-ROM (for Compact Disk-Read Only Memory) is capable of delivering large amounts of data in a convenient, inexpensive format. Besides the growing list of data sources for digital maps, the CD-ROM will likely become the format of choice in the near future – and for good reason. For example, the current version of AutoCAD requires 13 high-density 3½" diskettes to install the program. Also included is a CD- ROM with over 400 MB of utility files, text fonts, and sample drawings. While not required to run the program, this one CD-ROM costs far less to manufacture than the 13 diskettes.

Although Read Only Memory means the CD cannot be written to with a standard CD-ROM drive, manufacturers are now introducing rewritable CD-ROM drives which sell for about $400, a price that will drop as the technology advances.

System Distribution/Networking

While cities may continue to use large, central computers for municipal data processing, the trend in the computer industry is toward distributed computing systems. Small towns without mainframe computers often elect to purchase personal computers (PCs) for each department. Each PC has the capability to perform all the

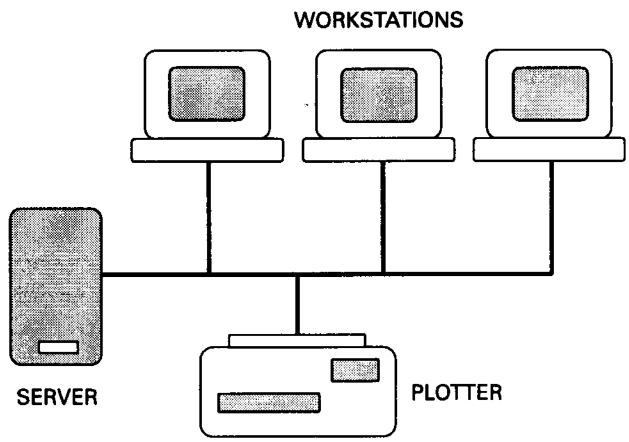


Figure 24. Network

department functions, without the need for a centralized mainframe computer.

When the need arises at a later time, these stand-alone computers can be linked together by connecting them to a "file server", and using certain software programs to form a "network". With a network, all the PC-users can share the data stored in separate department computers and the peripherals, such as plotters, printers, scanners, and the like. This is the essence of networking.

Like GIS, networking can be as simple or complex as required to satisfy the needs of the system. From a simple two-station local area network (LAN) within one department or connecting two departments to a sophisticated wide-area network (WAN) connecting all municipal departments, networking is accomplished successfully every day.

Because GIS demands sophisticated hardware on the desktop for performing the data input and analysis operations, a dedicated file server running a powerful networking system, such as Novell Netware, is required. Again, this is an industry full of buzzwords and acronyms -- Ethernet, 10Base T, Token Ring, SCSI-2, EISA, 10 MBit/sec, hubs, etc. -- so one must be careful to work with a reputable consultant who will provide the necessary service and explanation of the system's operation. As the network grows, it will become apparent that a knowledgeable and experienced network manager will be required.

Other GIS Planning Issues

Security of Files and Public Access

Security and privacy systems must be developed in an interdepartmental GIS. Certainly, the Assessor does not want the Water Department to modify the cadastral data and, likewise, the Water Department does not want the Assessor to change the location of a water service. Yet, both the Assessor and the Water Department have reason to access each other's databases.

Security and privacy systems are easy to put into place, but must be thought through and planned as part of the needs assessment. Also, the question of public access and costs to provide such access must be thought through carefully. Another issue is back-up and remote storage of data in the event of a fire or other accidental loss of data.

Use of Consultants

Finding the right consultant to advise on the development of a municipal GIS is a difficult -- but important -- issue to resolve. Individual consultants and consulting firms can provide everything from advice and guidance to complete "turnkey" systems, training, and technical support. Sometimes, consultants favor particular products and approaches, which, if one is not careful, could lead to a system that might not meet the needs of the municipality and/or is far too expensive.

Here are some suggestions to consider when embarking on a quest for a consultant:

- Define your purpose for needing a consultant, identify the objectives he/she is to accomplish, and state the criteria by which the consultant's services/products will be measured.
- Identify the credentials, area of expertise, education and experience you are seeking.
- State the work the consultant would perform.
- Describe your role and responsibilities and those of the consultant.
- Define the project schedule and the tasks to be accomplished within the schedule.
- Determine consultant fees, payment schedules, reimbursement of expenses.
- Write a contract type for the consultant to review and sign.
- Create a budget for the project and include fees for a consultant or consultants.
- Request and review work samples.
- Ask for references and check them.

Overall, selecting a consultant need not be difficult if one draws up a plan to guide the selection process. Ultimately, you and your colleagues must decide if this person is capable of building a long-term trusting relationship with you and providing the services/products your community pays for and expects to receive.

Appendix 2 contains a brief form to guide your selection of a consultant.

Personnel Training

The importance of training cannot be overemphasized. Having an operational municipal GIS in place means little if no staff are trained to use it. Unfortunately, while the recognition of the need for training is high, the implementation or funding of continuing training is often lacking. There are many stories of local governments spending considerable funds to design, develop and implement a GIS with little to no thought given to training.

To avoid the "system without users" syndrome, a training plan should be built into the overall GIS implementation plan. The training plan should be based on the learning needs of staff, which are identified by the needs assessment, and the skills/knowledge required to operate the system. In addition, the plan should specify the objectives of the training, courses and their sequence, and instructional methodology.

The latter item can be a thorny one because many consultants, if any are involved, and computer experts think that simply standing up and delivering a lecture is training. As viewed by technical training experts, especially when dealing with adults, training must be hands-on – experiential – so that participants learn by practicing on the system they will eventually operate and maintain. This approach to training is most effective because participants are actively learning compared with lectures and demonstrations, which are the least effective of all instructional methods because participants are passive listeners at best.

Who should design the training and instruct? There are several options. For example, if you have staff knowledgeable in GIS technology and with the skills needed to train, then use them for formal in-house training and on-the-job training. Another option is to enroll individual employees in computer courses at local educational institutions. Or send them to special training programs offered by computer-training organizations. Software vendors also offer training in their products.

Appendix 4 provides a list of several current education and training opportunities.

Learning from Other Municipalities

Visits to municipalities considering a GIS and others with an operational GIS can be very helpful to local officials during the "consideration" phase. They afford opportunities to ask individuals to share their concerns, experiences and advice, information your GIS committee can use to advantage as the concept of a GIS forms in their minds. The experience of other municipalities is important, because what you learn could save time, effort and money.

Appendix 8 describes the activities of several communities in New Hampshire that have implemented a GIS or are implementing GIS projects.

Summary

This chapter has focused on the choice of a GIS configuration, including the software, hardware and networking components a municipality must consider before implementing a system. Given the variety of components available today, choosing the "right" components can be a formidable task. However, with the proper guidance and advice from consultants and other municipalities that have implemented a GIS, the task can be made easier.

Also, this chapter has discussed several planning issues, such as training staff and selecting consultants, that typically arise when a municipality is considering a municipal-wide GIS. Recommendations for addressing and overcoming these issues were also presented.

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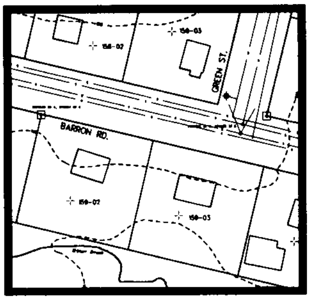


Chapter 5.

Building the GIS Database: Spatial and Tabular Elements

Introduction

As explained in Chapter 2 of this guidebook, a GIS combines two types of data: spatial or graphic data, which represent geographic features of interest, and tabular or text data, which represent the characteristics or attributes of map features. The GIS stores these textual and numerical data and their corresponding links to geographically referenced (spatial) objects in the graphic database.

This chapter examines the development of these data elements and provides some guidelines to local officials interested in implementing a GIS to meet the decision-making needs of local government.

Typical Municipal GIS Data

A municipality's GIS may contain several different categories of data, based on the intended uses of the system. Figure 25 illustrates the spatial and tabular data in a typical GIS database.

The Assessing layer, for example, would contain text and numerical data about each parcel in the tabular database, such as owner name, address, assessed value, zone, etc., and graphic data consisting of each parcel boundary stored in the spatial database.

Developing a Spatial Database

Sources of spatial data come in a variety of forms: maps, aerial photographs, drawings and plans that communicate the location, size or physical shape of geographic features. Typically, these mapped data are converted into computer form by means of digitizing or scanning, which capture and record the locations of mapped features as x,y coordinates. Converting data to usable computer format is the most expensive and time-consuming part of database development.

Spatial Database Layering

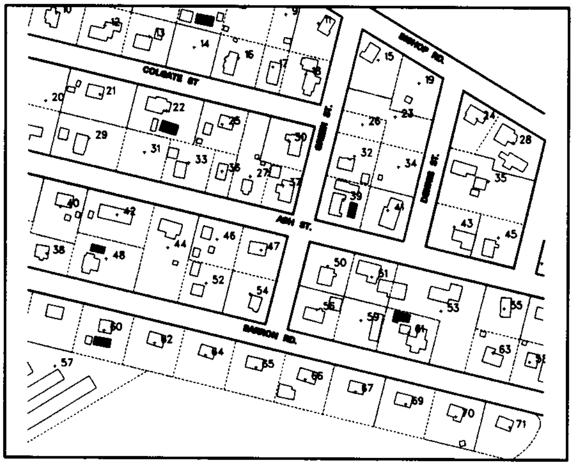
Organizing the municipal database into sets of thematically related layers with associated tabular (attribute) data is one of the first considerations in the spatial database design process. A typical municipal GIS spatial database can be organized into five themes of related layers, as follows:

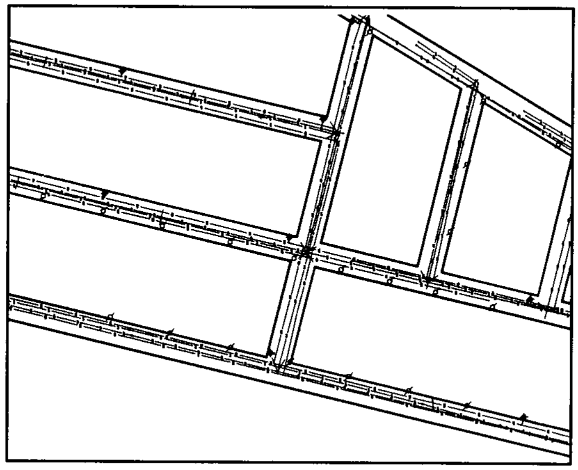
- Base map features
- Cadastral or parcel boundaries
- Infrastructure (utility systems)
- Natural features
- Administrative districts

Each of these five general themes may, in turn, consist of multiple individual data layers.

The importance and priority of the layers to be developed are determined through a user needs assessment conducted during the concept phase of a GIS project. Developing the spatial database is the single most expensive part of

GRAPHIC





TABULAR

ASSESSING

PROPERTY ID
ADDRESS
OWNER
MAP
BLOCK
LOT
STREET #
STREET NAME
CO OWNER
OWNER ADDRESS
OWNER CITY
OWNER STATE
OWNER ZIP
ACCOUNT NUMBER
DEED BOOK
DEED PAGE
OF CARDS
CARD #
LAND VALUE
BUILDING VALUE
TOTAL VALUE
SALES DATE
SALES VALUE
LAND USE 1
LAND ZONE 1
LAND USE 2
LAND ZONE 2
LAND AREA 2
TOTAL LAND AREA
ZONING
TRAFFIC ZONE
WARD
CENSUS BLOCK
SCHOOL

File Name

↓

BUILDING

PROPERTY ID
ADDRESS
OWNER
STYLE
MODEL
GRADE
STREET
STREET NAME
FUEL TYPE
HEATING TYPE
OF BEDROOMS
OF BATHS
OF ROOMS
OF STORIES
BUILDING VALUE
YEAR BUILT
GROSS AREA
EFFECTIVE AREA

↑

File Attributes

WATER SERVICE

WSERV #
PROPERTY ID
ADDRESS
STREET #
STREET NAME
VALVE TYPE
VALVE SIZE
SYSTEM
TIE 1
TIE 2
TIE 3
TIE 4
TAP SIZE
DATE SET
MAIN
DEPTH
REMARKS
MATERIAL
DEPTH
LENGTH
SIZE

WATER MAIN

LOCATION
STREET NAME
PRESSURE
LENGTH
DEPTH
MATERIAL
C VALUE
SIZE
LINING
DATE SET
ELEV NODE 1
ELEV NODE 2
FROM NODE
TO NODE
MGD
HGL
WMAIN #

SEWER SERVICE

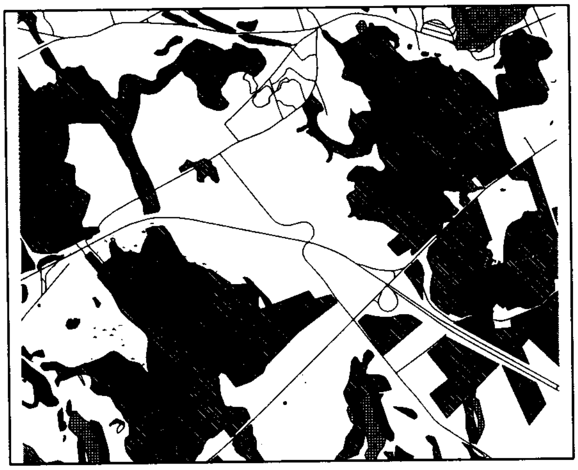
SSERV #
PROPERTY ID
ADDRESS
STREET #
STREET NAME
LOCATION
TIE 1
TIE 2
TIE 3
TIE 4
SIZE
LENGTH
DEPTH
MATERIAL

DATE SET
INSPECTION
VT RISE
SMAIN $

SEWER MAIN

LOCATION
STREET NAME
FLOW
LENGTH
DEPTH
MATERIAL
SIZE
DATE SET
FROM NODE
TO NODE
INVERT 1
INVERT 2
INVERT 3
INVERT 4
SLOPE
ELEV NODE 1
ELEV NODE 2

Figure 25. Municipal GIS Data

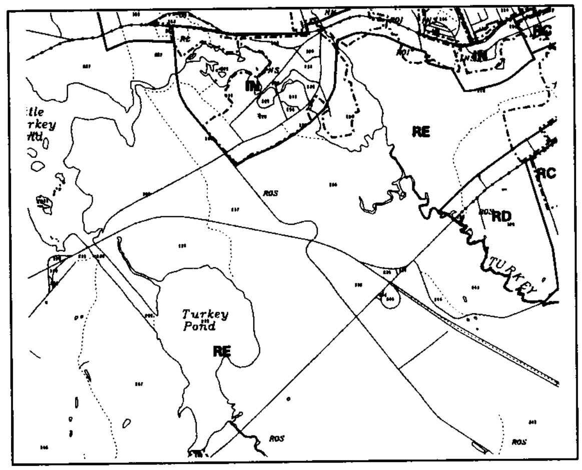


SOIL

SCS CODE
SOIL UNIT NAME
SLOPE
HYDRIC
PERMEABILITY
ERODIBILITY

CONSERVATION LAND

PROPERTY ID
ADDRESS
OWNER
PROTECTION TYPE
PERMITTED USES
ACCESS
HOLDER OF EASEMENT



ZONING

ZONING
MIN LOT SIZE
MIN FRONTAGE
FRONT SETBACK
SIDE SETBACK
REAR SETBACK
MAX HEIGHT
MAX BLDG %
MAX BLD/PARK %

TRAFFIC ZONE

TRAFFIC ZONE
HOUSING #
POPULATION
EMPLOYMENT
BUILD OUT POP
BUILD OUT EMP

WARD

WARD
VOTING PLACE
REPUBLICANS
DEMOCRATS
UNDECIDED
POPULATION 90

CENSUS

CENSUS BLOCK
TRACT #
BLOCK GROUP #
HOUSING %
POPULATION 90
POPULATION 80

Figure 25. Municipal GIS Data (Continued)

building a GIS for a community, so taking the time to plan its development is critical.

Base Map Features

The digital base map is the foundation for all subsequent spatial data layers. Typical categories of this layer include:

- Jurisdictional boundaries
- Geodetic control points
- Streets, roads, railroads, and other travelways
- Streams, lakes, ponds, and drainage features
- Surface (contour) topography

Topographic or contour data should be considered carefully due to the substantial cost of building and maintaining a topographic database. While these data can be added as needs dictate, a community should weigh the advantages and costs of this element in the initial GIS implementation.

Cadastral Layers

Cadastral data, displayed on the base map of a community, is commonly referred to as the Tax or Parcel Map. The cadastral layers contain data on the ownership or legal rights individuals have to the land. These data are based on written descriptions of properties and on physical locations usually found in legal documents, such as deeds. Other cadastral data maintained in the layer include:

- Property lines, lot and block identifiers, street addresses
- Easements, rights of way

Highly accurate and precise cadastral data may be expensive to collect and develop. Legal descriptions of parcel boundaries and their locations can be vague and/or conflicting. Boundary surveys may be necessary to determine actual locations, and further research to settle disagreements between abutters.

Infrastructure

Infrastucture usually includes public roads, drainage facilities, and utility systems. Private infrastructure elements also may be included. The following table lists types of infrastructure incorporated into a municipal GIS:

Many of these spatial data can be obtained from aerial photography or from existing records. Most can be represented adequately at a scale of 1"=100′, or 1"=50′ for very dense areas. Although some would argue for engineering design-based accuracy (1"=50′ or larger), this approach is not warranted for most municipalities because the cost far outweighs the benefits.

INFRASTRUCTURE ELEMENTS	
PRIVATE	PUBLIC
buildings fence lines pools driveways	buildings road systems curbing pipes guardrails sewer systems manholes drainage systems wire utilities water systems

Natural Features

The term ***natural features***, as used here, means data that describe the earth's surface or subsurface conditions. Natural features that should be considered for a municipal GIS include:

- Surface waters (in base map layer)
- Wetlands
- Soils
- Vegetation
- Geology
- Aquifers/surficial materials
- Topography (in base map layer)

Generally, natural feature boundaries are not sharply defined, because they tend to blend or transition from one "type" or condition to the next. Existing municipal, regional planning agency or the State's GRANIT System records can be used to build this database. It is important to recognize that the decision to include or to improve natural features data should be dictated by problems or priorities within each community. Again, determining these priorities is a function of a well-developed and systematically administered user needs assessment.

Administrative Districts

Administrative districts are subdivisions of a municipality established for the organization and conduct of various local government functions. Many of these district boundaries follow street and other physical features. There are exceptions, however, such as zoning district lines, which are drawn along parcel boundaries, or travel a certain distance offset from a feature, such as a road. These data can be no more accurate than the existing cadastral data shown on the municipal street map or on large-scale drawings of the tax or parcel maps.

Automating Spatial Data

In addition to deciding which data are important and prioritizing their automation, spatial database design must consider several factors, such as the data model (vector or raster); data layer organization; tiling schemes for segmenting the spatial data into manageable windows or mapsheets; and documentation. Each of these is discussed below.

Data Model - Vector or Raster

The computerization of spatial data from source materials can be accomplished using either a raster or a vector data model. The term "raster data" refers to cell data arranged in a regular grid pattern in which each unit (cell or pixel) is assigned a value based on some decision rule, usually the dominant or majority characteristic. The size of this grid cell may vary, depending upon the resolution or complexity of the features being represented, the scale of the source materials, and the types of applications anticipated. Because the data are captured as uniformly sized cells, the resulting digital map will have a blocky or stepwise appearance.

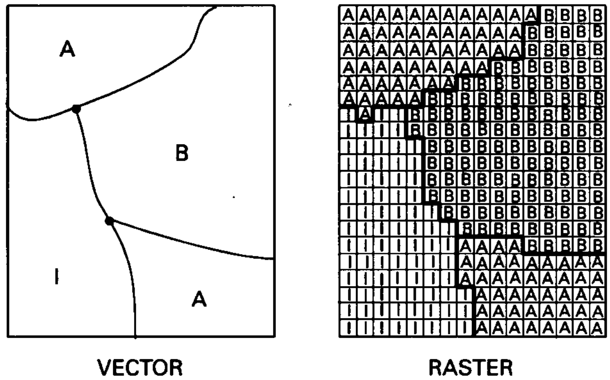


Figure 26. Vector and Raster Data

Vector data consist of x,y coordinate representations of locations on the earth that take the form of single points, strings of points (lines or arcs), or closed lines (polygons). The display of these digital data will conform closely to the shape and appearance of the features on the source documents.

The vector data model is commonly used to develop municipal GIS databases because of the greater degree of precision in capturing feature location and extent.

However, these two spatial data types are not mutually exclusive, and the more powerful GIS software packages are capable of accommodating both types. For example, raster data in the form of digital orthophotographs (i.e., computer-generated picture of an aerial photo with distortions removed) may be integrated with vector data to enhance the quality of data displayed for a community. Typically, raster data have been created through the use of a scanning device to convert maps and other source materials into digital form. (Increasingly, scanning is being used as the first step in the automation of vector data, as well.)

Scale and Accuracy

The scale of the spatial database and its accuracy are critical considerations in the database design process. (See Chapter 7 for a complete discussion of these terms.) Clearly, as the scale and accuracy of data compilation and capture increase, so do the associated data development

Table 2. Possible Base Mapping Scales				
Priority Area	**Type of Area**	**Density Pop/Sq Mi**	**Base Map Scale**	**Contour Interval**
1	Urban	more than 2,500	1" = 100' (1:1,200)	2 feet
2	Suburban	1,000	1" = 200' (1:2,400)	5 feet
3	Rural	250	1" = 400' (1:4,800)	10 feet
4	Rural	less than .20	1" = 2,000' (1:24,000)	20-40 feet

Table 3. Uses and Map Scales			
USE	**SCALE**		**CONTOUR INTERVAL**
Highway and Street Engineering and Water Support	1:24,000 1:2,400 1:480-1:1,200	(Master Plan, Watershed Area) (Preliminary location work) (Final design)	10-20 feet 5 feet 1 or 2 feet
Storm and Sanitary Sewer Engineering	1:4,800 1:2,400	(Preliminary location work) (Municipal)	2-5 feet 2 feet
Traffic Engineering and Street Lighting	1:9,600-1:24,000 1:1,200 - 1:2,400 1:240 - 1:480	(Generalized studies) (Planning and engineering) (Problem Areas)	
Planning	1:9,600 - 1:24,000 1:2,400 Various others depending on purpose	(Regional) (Municipal)	As appropriate As appropriate As appropriate
Tax Assessment	1:4,800 1:1,200 - 1:2,400 1:480	(Rural) (Suburban) (Urban)	
Utilities Location and Management	1:480		
City Surveys	1:480 - 1:1,200		1 or 2 feet
Parks and Recreation	1:24,000 1:1,200 - 1:2,400	(Area-wide) (Site Specific)	2 feet
Emergency Services	1:4,800; 1:9,600 or 1:24,000 (Depends on size of community)		

costs. Yet the parameters applied at the outset will dictate subsequent appropriate uses of the data. Both scale and accuracy should be established based on results of the user needs assessment.

Usually, a decision on the scale for cadastral layers will depend upon the density and/or size of individual parcels. If most of the land is divided into less than one-acre parcels, a 1"=100' (1:1,200) map scale is appropriate. For an area where most parcels are between one and two acres, a map scale of 1"=200' (1:2,400) is suitable. For rural areas where most of the land is in larger parcels, 1"=400' (1:2,400) or 1"=400' (1:4,800) map scale is appropriate.

Suggested scales for various developmental densities are shown in Table 2. Different scales within a single municipal GIS may be used, with the urban sections mapped at a larger scale and the rural areas at a smaller scale.

Another way of evaluating map scales, depending upon the intended use of the maps, is illustrated in Table 3.

Some communities have computerized and adjusted their existing maps to conform to the 1"=2,000' (1:24,000) USGS topographic base maps. While this approach produces a general picture of the parcel boundaries and yields useful information for certain planning purposes, it will fall far short of the long-term needs of local government. Generally, spending money to digitize existing tax maps, which were not produced using an orthographic (constant scale) base, is not recommended. Abutting map edges will not align properly, and considerable effort would be required to "rubber sheet" the individual tax sheets so that they match.

Map accuracy requirements constitute another important factor, and must be considered in conjunction with map scale issues. As with map scale, accuracy guidelines may vary with the density of development and the anticipated uses of the data. For example, in a densely developed urban area with lot frontages of less than 40 feet, accuracy standards of 1.5 feet may be appropriate. This standard dictates that 90 percent of the features will be mapped within 1.5 feet of their true location. However, in more rural areas where lot frontages extend to 200 feet and more, accuracies in the range of 12 feet may be adequate. Table 4 further describes the relationship between map scales and map accuracies.

Table 4. Expected Accuracies Using National Map Accuracy Standards

SCALE	CONTOUR INTERVAL	HORIZONTAL ACCURACY	VERTICAL ACCURACY*
1" = 100' (1:1,200)	2 feet	3/3 feet	1 foot
1" = 200' (1:2,400)	5 feet	6.7 feet	2.5 feet
1" = 400' (1:4,800)	10 feet	13.3 feet	5 feet
1" = 2,000' (1:24,000)	20-40 feet**	40 feet	10-20 feet

**90% Confidence Level* ***Typical*

Registering Spatial Data

In a layered GIS database, the base map and registration or control points together create the spatial framework which ties each data layer to all others. A system of registration points must be provided on each map sheet to enable the sheets to be used in conjunction with one an-

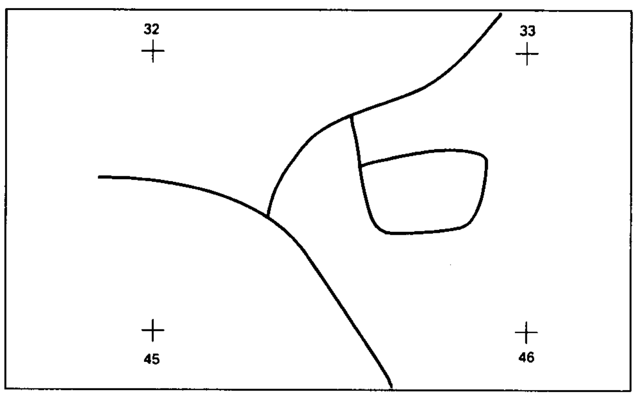


Figure 27. Registration

other. These registration points should have associated coordinate locations recorded in a standard coordinate system, preferably New Hampshire State Plane coordinates.

See Chapter 7 for a detailed discussion of coordinate systems.

Tiling Spatial Data

Geographic information systems often segment spatial layers into tiles of uniform size and shape. This approach improves spatial data access, facilitates file management, and assists in disk space utilization associated with map layers. Tile boundaries should be stable, not subject to frequent change, and should be simple geometric shapes, such as rectangles or squares.

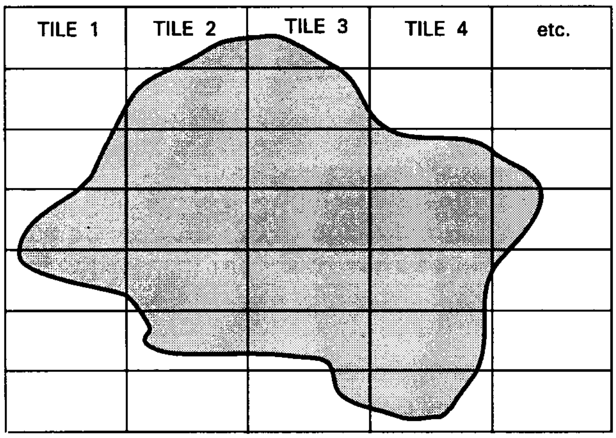


Figure 28. Simple Spatial Tiling Scheme

Tile size should be chosen to enhance – not degrade data access and retrieval. Selecting the appropriate size may require some testing. One option for a broad framework of a municipality's tiling scheme is the USGS quadrangle boundaries and subdivisions at 7.5 minute, 3.75 minute, and smaller intervals.

Documentation

A system for documenting the source, scale, accuracy and other aspects of each data set must be developed. Documentation includes a data dictionary and data history file. The data dictionary contains "meta-data" or data about data, information about each data file in terms of source and custodial responsibilities, scale, accuracy and resolution, and quality. The data history file records data development and changes made to the database as they are entered.

Good documentation will be useful when updating and expanding the spatial database. Since most spatial data are related to other data, it will be essential to know which pieces are most accurate and/or most current. It is easy to document changes as they are made, but far more difficult to reconstruct spatial data that may be a year or two old. Developing and using a system of approvals for change is necessary if a town or city is to take full advantage of a GIS as a spatial database manager.

Utilizing the Data – Map Output

For map production, a municipal GIS offers many significant advantages over a manual approach. Among these are the following powerful map production functions:

- Producing maps of all or portions of the municipality at different scales;
- Altering spatial layers, as needed, to account for changes as they occur;
- Combining layers to produce new maps to depict different views of the community;
- Producing output in different formats, such as animated video, slides, etc; and
- Enhancing the cartographic presentation of mapped data.

Adopting standards for plotting spatial features is an important consideration for municipalities. Groups, such as the NH Municipal Engineers Council, are exploring GIS standards for items such as layer names, line colors and weights, and symbols for point features. This will facilitate the transfer of digital data from one municipal GIS to neighboring communities and regional agencies for multi-community studies and analyses.

When developing the user needs assessment and planning the spatial database, a list of reports to be produced on a regular basis, such as maps or plans, should be prepared. For example, updated tax maps should be plotted annually on the first of April, or snow plow routes updated and plotted in September of each year. With a properly functioning GIS, there are no longer any excuses for using outdated street, water, sewer or other information to guide management and planning decisions.

Developing a Municipal Tabular Database

Tabular databases (also called textual or attribute) are organized much like a spreadsheet, with rows and columns. The vertical columns are called fields and the horizontal rows are called records. Table 5 is a sample database table that stores data about parcels of land for assessing purposes. Each record contains eight fields about a single piece of property. In the database table, there are ten records with data about ten pieces of property.

Tabular Database Design

A database management system (DBMS) is used to maintain tabular data in a GIS. Most software packages accommodate tables that can store unlimited numbers of records and at least 254 fields of data per record, depending upon the computer being used and its storage capacity. In addition, many of the standard database packages are relational, indicating that individual tables may be linked together based on a common field. The ability to relate tables effectively extends the number of fields accessible per record well beyond any typical requirements.

The process of developing GIS tabular databases can start long before any GIS software is

Table 5. Sample Assessing Database Table

FIELDS ↓

	PROP ID	NAME	ADDRESS	VALUE	AREA	USAGE	ZONE	WARD
RECORD →	1-1-1	JONES	23 MAIN ST	155000	13000	1	RA	3
	1-1-2	SMITH	25 MAIN ST	161000	12500	3	RA	3
	1-1-3	DAVIS	27 MAIN ST	149000	11345	2	RA	3
	1-1-4	REED	17 ELM ST	171000	9000	1	RA	3
	1-2-1	LEE	18 ELM ST	148000	12876	4	RA	3
	1-2-2	O'BRIEN	29 MAIN ST	158000	10987	2	RB	3
	1-3-1	MARSH	24 MAIN ST	154000	13987	1	RB	3
	1-3-2	BERG	26 MAIN ST	164000	12098	2	RB	3
	1-3-3	WALZ	28 MAIN ST	173450	11986	3	BA	3
	1-4-1	COOK	30 MAIN ST	167000	10198	1	BA	3

Table 6. Sample Database Structure			
DATABASE TABLE NAME: PROPERTY			
	PROPERTY NAME	FIELD TYPE	FIELD WIDTH
FIELDS	Property ID	Numeric	Max 7 Characters
	Owner	Character	Max 30 Characters
	Address	Character	Max 30 Characters
	Value	Numeric	Max 14 Numbers
	Area	Numeric	Max 6 Characters
	Usage	Numeric	Max 1 Character
	Zone	Character	Max 5 Characters
	Ward	Numeric	Max 2 Characters

purchased. Many communities already have computerized tax rolls and assessments. These data can be transferred to a GIS when needed. Other data, such as zoning, permits and utility records, can be recorded on paper or 3"x5" cards and then computerized. Much of this work can be accomplished "in-house" by staff, thereby improving record-keeping and data retrieval immediately.

Creating a database or database table is straightforward but should be carefully designed. The user simply defines the parameters of the table to be created, including naming the table, defining fields, and setting size and field type for each field. Most database software allow the user to edit the table structure after it has been created. Table 6 illustrates a sample database structure.

As a general principle, duplicate fields in different tabular databases should be avoided unless the field is acting as a relational link. (In a standard municipal database, the parcel identifier often functions as the link between multiple tables.) Carrying duplicate data, such as property owner name and address, in several databases requires considerable effort to maintain consistency in spelling, abbreviations, and the like. Retaining redundant data is also inadvisable from the perspective of efficient disk utilization.

When creating databases, it is important to set up standards to permit relation of one table to another, and to enable fast data retrieval and entry. The following discussion contains several standards that should be observed.

Field Formatting and Entry

Standards are critical for field formatting and for subsequent data entry. Decisions must be made regarding the type of data stored in each field. For example, property owner names may be entered in one field containing the full name, or the last name, first name and middle initial may be stored in three individual fields. Seemingly simple decisions like these will impact the user's ability to sort, query and retrieve the data in the future.

Proper data entry should also be described in a set of written standards. The "rules" should define clearly the order of data entry in fields, the use of capitalization, and the use of abbreviations, as in the following:

Names: Last, First, MI
Streets: St., Ave., Rd, Ln.
Sizes: In., Ft., Ac.

The following tables illustrate a database with and without standards for field formatting and data entry:

Good Property Table

Owner	Address	Value
Jones, David	119 Elm St	199000
Lee, Chris	121 Elm St	178000
Topp, Daniel	71 Ash Rd	145000
Foxx, John	8 Davis Rd	210000

Bad Property Table

Owner	Address	Value
Jones, David	119 Elm St	199,000
Lee Chris	121 Elm St	178000
Topp, Daniel	71 Ash RD	145,000
FOXX, JOHN	8 Davis Road	210000

Coding

Tabular databases may contain fields with codes that summarize or generalize characteristics. For example, the zone in which a parcel is located may be represented by R1, meaning low density residential uses. Rather than entering the full zoning district name repetitively and thereby increasing the chance for error and increasing the data storage requirements, it is customary to rely on codes.

Database Efficiency: Indexing

Data retrieval speed is always an important consideration. Generally, the larger the database becomes, the slower the speed of retrieval. One way to increase the speed and efficiency of database operations is to index fields that are used most often.

For example, consider data pertaining to property records residing in a database table named PROPERTY. This table has 10,000 parcel records and 20 fields (owner, address, value, etc.) of data per record. The most common query asks for information based on property owner names. So, to make the database more efficient, an index would be created on the field OWNER.

Examples where indexes would be helpful are illustrated below:

List Owner, Address, Value where Owner = 'BARBOUR' (** Index on Owner field would help)

List Owner, Address, Value where Zone = 'BA' (** Index on Zone field would help)

An index should be created for all fields that are queried frequently. Indexing too many fields, however, slows down database operations because, as the database is updated, all indexes must also be updated.

Data Documentation

Good information system administration, no matter what the application, dictates that the contents of the tabular database be well documented. Documentation should occur at several levels:

- detailed descriptions of the database structure, including definitions of fields, codes used and other information necessary for maintaining consistent data; and
- updates and changes to the database.

As discussed in the Spatial Database Documentation section (above), great care must be taken to keep track of the database's history.

Collecting and Automating Data

Data collection is the process of obtaining text data and entering them into a database. Two methods are used – manual entry and data translation:

- ***Manual Entry***, sometimes referred to as hand- keying, is used when data reside in paper records. Manual entry is a time-consuming process that involves typing each record into the database table. Once in the database, however, the data are there for good. In some cases, it may be possible to scan paper records. Whether entered manually or scanned, a quality control system should be used to minimize data-entry errors.

- ***Data Translation*** entails retrieving data from existing databases and then uploading them into another database. Typically, if data are stored in any computer system, they can be translated from one database into another. When municipalities build a GIS, most are able to download data, such as property records, from an existing data management system.

Utilizing Data: Reports

Once entered into a database, data can be retrieved, manipulated and reported in many different ways. Retrieving data (also called querying the database) is a simple procedure requiring the user to specify one or more data fields and adding, if desired, a selection condition. The following examples illustrate the procedure:

List Owner, Address, Value from the Property Database where Value <100000

List Owner, Address, Value from Property Database where Owner = 'Smith, John'

List Street, Pipe#, Length from Water Pipe Database where Length >1000

Queries can also be used to obtain counts, totals and statistics about the database contents. For example, a user may ask for the total length of pipe installed before 1930 or the total and average property value in a certain area of the community.

Utilizing Data: Linkages Between Databases

As mentioned above, relational linkages between two (or more) database tables may be created based on fields common to both if a relational database package is used. This affords a user simultaneous access to all fields in all related tables. Figure 7 illustrates common linkages among several municipal database tables.

As shown in Table 7, the Address field resides in the Assessing, Building, Water Service, and Sewer Service tables. If there is a query to extract data from the Assessing table at 67 Main St., the linking address field allows access to the other tables containing the field Address having a value of 67 Main St. With one query, a user would be able to display the following data about this address:

- Assessed Total Value from the Assessing Table;
- Building Style and Gross Area from the Building Table;
- Water Service Size from the Water Service Table; and
- Sewer Service Location from the Sewer Service Table.

The same type of data would be retrievable within a non-relational database environment, but might require as many as four independent queries.

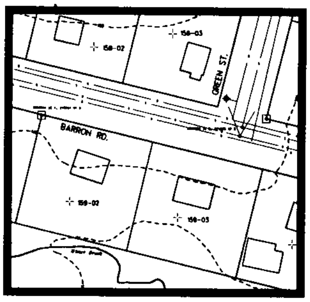
Summary

This chapter has discussed the two elements of a GIS database: spatial and tabular data. The publications listed in Appendix 3, Suggested Readings, contain more information on these topics. Of particular interest is the "Multipurpose Land Information Systems: A Guidebook", published by the Federal Geographic Coordinating Committee in 1993.

Table 7. Sample of Related Database Tables

ASSESSING	BUILDING	WATER SERVICE	SEWER SERVICE	SEWER MAIN
PROPERTY ID	PROPERTY ID	WSERV #	SSERV #	LOCATION
ADDRESS	ADDRESS	PROPERTY ID	PROPERTY ID	STREET NAME
OWNER	OWNER	ADDRESS	ADDRESS	FLOW
MAP	STYLE	STREET #	STREET #	LENGTH
BLOCK	MODEL	STREET NAME	STREET NAME	DEPTH
LOT	GRADE	VALVE TYPE	LOCATION	MATERIAL
STREET #	STREET #	VALVE SIZE	TIE 1	SIZE
STREET NAME	STREET NAME	SYSTEM	TIE 2	DATE SET
CO OWNER	FUEL TYPE	TIE 1	TIE 3	FROM NODE
OWNER ADDRESS	HEATING TYPE	TIE 2	TIE 4	TO NODE
OWNER CITY	# OF BEDROOMS	TIE 3	SIZE	INVERT 1
OWNER STATE	# OF BATHS	TIE 4	LENGTH	INVERT 2
OWNER ZIP	# OF ROOMS	TAP SIZE	DEPTH	INVERT 3
ACCOUNT NUMBER	# OF STORIES	DATE SET	MATERIAL	INVERT 4
DEED BOOK	BUILDING VALUE	MAIN #	DATE SET	SLOPE
DEED PAGE	YEAR BUILT	DEPTH	INSPECTION	ELEV NODE 1
# OF CARDS	GROSS AREA	REMARKS	VT RISE	ELEV NODE 2
CARD #	EFFECTIVE AREA	MATERIAL	SMAIN #	SMAIN #
LAND VALUE		DEPTH		
BUILDING VALUE		LENGTH		
TOTAL VALUE		SIZE		
SALES DATE				
SALES VALUE				
TOTAL LAND AREA				
ZONING				

ZONING
ZONING
MIN LOT SIZE
MIN FRONTAGE
FRONT SETBACK
SIDE SETBACK
REAR SETBACK
MAX HEIGHT
MAX BLDG %



Chapter 6.

Integrating Data from Other Sources

Introduction

There are a number of ways communities can gain access to existing digital data in order to start building the GIS database. This chapter explores some of the sources available from regional, state, and federal organizations. Even communities with an operational GIS may find some of these data sets potentially useful. In most cases, the data described are either free or available at a nominal charge.

Several factors should be considered as data are imported from external sources:

- First, digital data acquired from other sources should be documented for map scale, accuracy and resolution. Once the standards used to develop the data have been checked, the data and their use can be assessed.
- Second, once the reliability and quality of the data are documented, then one has to determine whether the data can be imported into your GIS database. Most standard GIS packages have capabilities to import data from other systems. Usually, the graphics component of data can be imported successfully to other systems. However, the link between the graphics and the attribute data is sometimes lost during the translation process. Solutions to this problem may be available.
- Third, even if the data are transferred successfully, the coordinate reference framework to which the data are tied might be different from your community's framework. Again, most standard packages provide tools to project data from one projection-coordinate framework to another.

The remainder of this chapter presents basic information on various sources of digital data. This listing is not comprehensive, but represents a cross-section of organizations that regularly develop and distribute spatially referenced digital data for New Hampshire.

GRANIT - The Statewide GIS

In 1984, the New Hampshire Office of State Planning (OSP) established a cooperative GIS project with the Complex Systems Research Center (CSRC) at the University of New Hampshire. The primary objective of this project is to apply computer mapping to land-use planning and resource management problems. Since its inception, OSP and CSRC have continued to develop this GIS, called the NH GRANIT (Geographically Referenced Analysis and Information Transfer) System, and to coordinate this activity with other regional, state and federal agencies involved in resource management and protection. Applications and database development are carried out by CSRC under an annual funding agreement with OSP.

The core of the GRANIT System is its layered database. As with all functional geographic information systems, the database is undergoing constant revision and expansion in accordance with its strategic development plan. Table 8 lists the data layers either being developed or targeted for development. The full contents of the database are described in the NH GRANIT Data Catalog, which is available from OSP or CRSC.

Table 8. NH GRANIT Data Base

DATA LAYER	SOURCE	AUTOMATION
GEOLOGY/SUFICIAL MATERIALS		
Bedrock Geology	NH GS	OSP/CSRC
Surficial Geology	NH GS	OSP/CSRC
Soil Units	SCS	OSP/CSRC
TERRAIN		
Elevation	USGS	OSP/CSRC
Bathymetry	USGS/Various	CSRC
HYDROGRAPHY		
Hydrography - Surface Waters	USGS	DOT/USGS/CSRC
Aquifers	USGS	CSRC/USGS
Watershed Boundaries	DES	DES
Wetlands (NWI)	USF&WS	DES
Wetlands - Marsh Deposits	NH GS	DES
Wetlands - Landsat TM Data	EOSAT	OSP/CSRC
Wetlands - Coastal	OSP	CSRC
Well Inventory	DES	DES
Floodplains	FEMA	OEM/OSP
LAND USE		
Land Use	Towns/RPA's	RPA's
Land Use Changes	UNH	OSP/UNH/CSRC
Transportation Facilities	USGS	DOT/USGS/CSRC
Roads	USGS	DOT/USGS/CSRC
Railroads	USGS	DOT/USGSCSRC
Pipelines	USGS/PUC	DOT/USGS/PUC
Water Supply Service	DES	DES/PUC
Sewer Service	DES	DES
Outdoor Recreation Facilities	DRED	OSP
Historic and Archaeologic Sites	DLAHR	OSP
ENVIRONMENTAL FACTORS		
Agricultural Pesticides	DES/Agr.	DES/OSP/CSRC
Point Sources	DES	DES/RPA's
Non-point Sources	DES	DES
LAND COVER		
Land Cover - Landsat TM Data	EOSAT	OSP/CSRC
Forest Survey Data	DRED	OSP/CSRC
Natural Heritage Inventory	DRED	OSP/CSRC
Wildlife Habitat	EOSAT/F&G	OSP/CSRC
BOUNDARIES		
Political Jurisdiction Boundaries	USGS	DOT/USGS/CSRC
Zoning District Boundaries	Towns, Cities	OSP/RPA's
Statistical Boundaries - Census	US Census	US Census/CSRC
Publicly Owned/Protected Lands	USGS/OSP	OSP/CSRC
Geodetic Control	NOS-NGS, DOT	DOT

There are a number of fundamental standards applied to the development of GRANIT data.

- The data are registered to New Hampshire State Plane coordinate feet, NAD 1983.
- The data development target scale is 1:24,000 or 1 inch = 2,000 feet. In certain instances, the scale of a particular data layer will deviate from this norm. For the most part, this occurs in cases where the data layer of interest has not been mapped at the targeted scale (e.g., bedrock geology).
- Most data are developed, archived and distributed in "tiles" that correspond to the standard U.S. Geological Survey (USGS) 7.5-minute quadrangles. The storage tile may vary for some data layers, usually because the data complexity does not warrant archiving in such small geographic units.

Access to GRANIT data is granted without restriction, except in certain specialized cases where the data layer is considered sensitive. Interested parties are asked to submit a "Data Request Form", available from CSRC. A nominal fee, covering the cost of data reproduction, is charged.

NH Office of State Planning
2½ Beacon Street
Concord, NH 03301
Tel: 1-603-271-2155

or

GRANIT Program Manager
Complex Systems Research Center
Morse Hall
University of New Hampshire
Durham, NH 03824
Tel: 1-603-862-1792

Regional Planning Agencies

New Hampshire's nine regional planning agencies (RPAs) coordinate local planning efforts on a regional basis, furnish technical planning assistance to member municipalities, and provide GIS data.

To support the RPAs, the New Hampshire Legislature, in 1989, provided funding to equip all RPAs with complete GIS pc-based workstations. Three goals were set:

- To promote the use of GIS as a planning tool at the local and regional levels;
- To extend the utility and availability of the NH GRANIT System to the local level; and
- To develop knowledge and understanding of GIS at the RPA level to be passed along to municipalities when they begin to develop their own GIS applications.

Since establishing their geographic information systems in 1989, the RPAs have integrated GIS in much of their regional and local planning work, and have become major users of GRANIT data. In addition, the data developed by the RPAs for their own needs, including coverages for land use, zoning, pollution sources and public lands, are made available through the NH GRANIT System to other users.

Municipalities can get direct access to the NH GRANIT System database through their regional planning agency. Most RPAs can readily assist communities in extracting the coverages needed, clipping them to the appropriate municipal boundary, updating them, as needed, and exporting the data to any of a number of supported data exchange formats.

Depending upon the agency and the scope of the work to be performed, these services may be provided as a member service or may require a special contract. Most RPAs have begun to develop town-specific applications for their members in conjunction with specific planning projects carried out over several years. If developed at the same or similar scale, and on an appropriate base map (i.e., one that is tied to the NH State Plane Coordinate System), this prior work can be integrated into a municipal GIS.

In addition to NH GRANIT System data, the RPAs develop data and coverages for their project-specific needs, which, when completed, are made available to municipalities. Examples of these applications include zoning districts, existing land use, and watershed management plans.

U.S. Geological Survey

Digital versions of the cartographic information shown on U.S. Geological Survey (USGS) topographic maps are produced at scales ranging from 1:24,000 to 1:2,000,000. Digitized lines from these quadrangle maps are called digital line graphs (DLG), and are available at the detailed scales of 1:24,000 or 1:25,000 for specific features. They are ordered by feature type and quadrangle map area.

Complete coverage is available for the State of New Hampshire for the following features:

- Political boundaries for towns and cities, and for publicly owned lands, such as the White Mountain National Forest;
- Transportation, including roads and trails, railroads, pipelines and transmission lines; and
- Hydrography, including rivers, streams, marshes, lakes and ponds.

The digitized features are the same as those shown on the published USGS quadrangle maps and, therefore, are limited to features existing at the time the aerial photography was obtained for each map. A footnote in the lower left corner of each quadrangle map states when the photography was obtained, and this date is incorporated in the DLGs, as well. For the most part, aerial photography for the State dates to the early 1980s, although some photography dates to the 1950s.

The USGS Earth Science Information Center also has the digitized topographic contours (called hypsography DLGs) for some 1:24,000 scale quadrangle maps. At present, these are available for very limited areas in New Hampshire.

Also available from the Center are digital elevation models (DEMs), which are records of the land surface at approximately 100-foot intervals. The accuracy of the elevation data at this scale varies depending on the contour interval of the source map. This data set covers about 60 percent of the State.

A brochure, entitled Catalog of US Geodata, and order information are available from the following organizations:

Earth Science Information Center
U.S. Geological Survey
Room 1C402
507 National Center
Reston, VA 22092
Tel: 1-800-USA-MAPS

or

ESIC Affiliate
Dimond Library
University of New Hampshire
Durham, NH 03824
Tel: 1-603-862-1777

The New Hampshire and Vermont District of the USGS's Water Resources Division is producing a series of aquifer maps that will cover the entire State. The State has been divided into 12 study areas for mapping purposes, and data produced at a scale of 1:24,000 or 1:25,000, are presently available for a subset of these. The information shown on the aquifer maps, and recorded in the digital files, includes aquifer boundaries, well data locations, water table altitude, saturated thickness, and transmissivity. Coverage is available from Complex Systems Research Center at the University of New Hampshire or the NH-VT District of the USGS. The published maps and reports are available from:

U.S. Geological Survey
525 Clinton Street
Bow, NH 03304
Tel: 1-603-225-4681

Soil Conservation Service

The Soil Conservation Service (SCS) utilizes the Geographic Resources Analysis and Support System (GRASS) as its geographic information system. GRASS was developed by the U.S. Army Corps of Engineers and is UNIX-based. It performs the five basic functions of most GISs: data input, storage, manipulation, analysis, and display. GRASS is a public-domain system, and is used and supported by several federal agencies.

SCS has established three soil geographic databases, each representing different scales of soil mapping for different uses:

- National Soil Geographic Database (NATSGO) has the smallest scale (typically 1:7,500,000) of the three, and can be used for national and regional resource planning and monitoring.
- State Soil Geographic Database (STATSGO) has a general mapping scale (typically 1:250,000), and is used primarily for river basins, state and county resource planning, management, and monitoring.
- Soil Survey Geographic Database (SSURGO) uses the largest mapping scale, is the most detailed of the three available databases, and is used primarily for conservation planning and for town, county, and watershed resource planning and management.

The SCS New Hampshire soil maps are digitized by the Complex Systems Research Center, and reviewed and edited by the SCS in accordance with the standards and specifications of the National Cooperative Soil Survey (NCSS). Spatial data are only a part of the SCS GIS. Attribute data, in association with the spatial data, allow the maps to be used for a variety of purposes, such as planning. Soil information available through the New Hampshire State Soil Database includes soil descriptions, physical and chemical engineering properties, and soil interpretations.

The following summarizes the status of county soils maps in New Hampshire:

- Digital soils data available: Carroll, Grafton, Hillsborough, Rockingham, and Strafford
- Soil maps completed and automation in progress: Cheshire
- Soil maps being recompiled in preparation for automation: Sullivan
- Soil mapping underway: Belknap, Coos and Merrimack

For more information regarding the availability and characteristics of the digital geographic data and soil attribute data, contact:

State Soil Scientist, USDA-SCS
2 Madbury Road
Durham, NH 03824
Tel: 1-603-868-7581

For information on the availability of soil maps, contact your local Conservation District.

Commercial Imagery

EOSAT

The Earth Observation Satellite Company (EOSAT), Lanham, Maryland, maintains an extensive library of more than 2.5 million images acquired by the various Landsat satellites. The data have been collected continuously since the launch of Landsat 1 in 1972.

EOSAT offers data sets as photographs or digital products from the Multispectral (MSS) and Thematic Mapper (TM) sensors. The MSS imagery provides data in three bands of the electromagnetic spectrum and has a spatial resolution of 80 meters. The TM data offers both increased spectral resolution (data in seven bands) and increased spatial resolution (30-meter pixels). The full Landsat scene covers a ground area of 185 km x 170 km, but purchasers have options for ordering quarter scenes, mini scenes, and other data subsets.

While the scale of this satellite imagery is generally too small for many municipalities, the imagery does offer a means to obtain a regional view. Furthermore, since the data has been continuously acquired over two decades, the imagery provides a means to assess and monitor change in landscape characteristics.

SPOT

SPOT (Satellite Pour l'Observation de la Terre) is the name of three satellites launched and maintained through the cooperative efforts of several European space agencies. The purpose of these satellites is to observe and transmit acquired images of the earth to a global network of ground receiving stations.

SPOT data are available in various scales, typically 1:24,000 or smaller. The data are delivered as a print, a film, or on one of the many digital media, such as CD-ROM, 8mm tape, 180MB QIC tape, 4mm DAT, and 9-Track. A value-added product, called SPOTView, is delivered following significant cartographic processing and is readily incorporated into many popular GIS software programs. Since 1986, over three million images have been acquired by the satellites, and images are added daily.

SPOT Image Corporation of Reston, Virginia, distributes global SPOT imagery to the US marketplace.

Summary

The availability of spatially referenced digital data from a variety of sources offers an inexpensive means for municipalities to expand current GIS database capabilities or to consider as elements in a new GIS. The sources of these data include a number of private- and public-sector organizations, including the New Hampshire GRANIT System, regional planning agencies, the U.S. Geological Service, Soil Conservation Service, EOSAT (Landsat) and SPOT.

Each of these external sources must be checked for quality and reliability before they are entered into a GIS database. Overall, municipalities should consider the use of these digital data at some time during the development of a GIS, because of their reasonable price and their potential usefulness.

Chapter 7.

Base Mapping and Geodetic Control

Introduction

All geographic information systems begin with maps, which come in a variety of forms and have a variety of uses. In the next few pages, we'll describe several types of maps, how they are made, and what they can and cannot do for you and your community.

What Are the Types of Maps?

The flat paper map is the most common and familiar type of map. Examples with which you are familiar include road maps and topographic maps, such as the one shown below. While the purpose of the former maps is to help you determine a route for getting to one place from another, the purpose of the latter is to help you visualize the physical world around you.

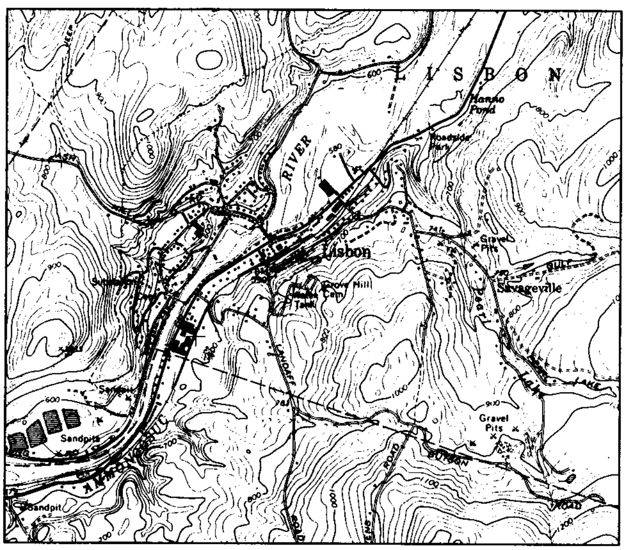


Figure 29. USGS Topo Map

Although these 2-dimensional, flat representations of a 3-dimensional, curved earth work reasonably well for most of us, they impose on us a need to accept its flattened view of the world. Fortunately, the world is neither flat nor 2-dimensional.

To correct this problem, mapmakers created globes and other 3-dimensional maps. These maps provide a more realistic representation of the earth's surface.

Figure 30. Globe

Although useful in helping us visualize the contours of the earth's surface, these maps are not as convenient to use as the flat map because the scale of objects is too small. Besides, these maps are not as portable as flat maps.

A product of the hi-tech world in which we live is the computer-generated or digital map. Whereas 2-dimensional paper maps are unchanging once they are printed, the digital map is as dynamic as the data displayed on the com-

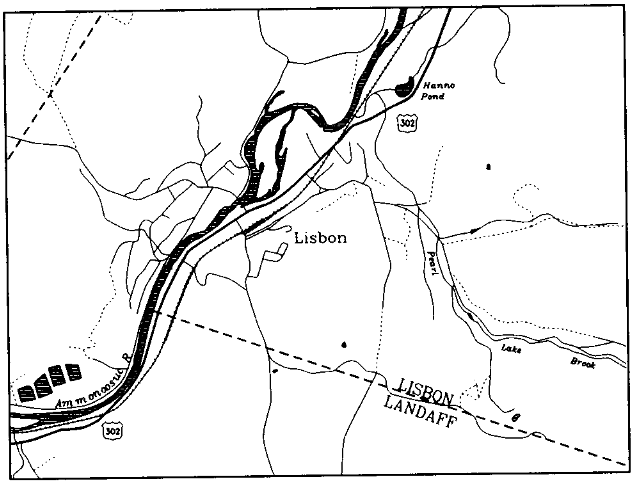


Figure 31. Digital Plotted Map

puter screen and as current as the last data entered into the computer's database. Figure 31 is an example of a digital plot.

But even digital maps become static when plotted on paper.

Where Do Maps Come From?

Up until recently, mapmakers drew maps manually. Although they produced many beautiful, detailed maps, the process of designing them, selecting the set of features to be shown on them and properly locating those, was sometimes subjective. As a result, it was the mapmakers' individual choices that influenced our perception of the earth's surface and manmade features, and thereby impacted how we used the information.

With the use of digital technology, today's mapmakers may have some advantages over their predecessors. They have rapid access to computer screens and large electronic databases, and can assess many different map designs before selecting a final display version. It is worth noting that the element of subjectivity has not been eliminated, since mapmakers still must use judgement in selecting the set of features to display on a map, and determining the way that feature set will be symbolized. Consequently, the mapmakers' choices continue to influence the way we perceive and use maps.

Designing and producing maps is a long, complicated, and sometimes expensive process. Being aware of how the mapping process works will help you anticipate how your community can use the maps and ensure that the money and time spent will not be wasted.

Maps have varying degrees of reliability and contain many types of information for many different uses. Planning boards or municipal engineers use maps to make decisions which affect an entire community. If the data upon which the maps are based are poor, then poor maps will be produced. It is possible that the resulting decisions might also be inadequate.

One of the most critical factors that determines the accuracy of your maps is the quality of the ***geodetic control network***. The network consists of monuments, called ***points***, whose accurate location on the earth's surface is established through surveying. When aerial photographs are taken, these points are recorded on film. Mapmakers then use these points to determine a map's scale and to locate physical features on the map in accordance with National Map Accuracy Standards or ASPRS standards.

Since the accuracy of the geodetic control network is such a critical factor in producing accurate, reliable maps, we encourage you to spend a little more time and money to establish a network before implementing any further plans for a geographic information system.

What Is a Base Map?

Forms of Base Maps

A major factor that determines the reliability and utility of mapped information is the accuracy of the base map on which the data are displayed. There are many different types of base maps used in geographic information systems. The most common forms include ***line maps, orthophoto maps***, and ***satellite imagery maps***. Each has its advantages and disadvantages. However, the type your community selects will depend upon several considerations, including intended use, cost, existing mapping and the degree to which you will become involved in the map-development process. The line map, for example, is the most common form for municipalities.

Line Maps

We are most familiar with line maps, such as road maps and topographic maps. Everything shown on a line map is a symbolic representation of real-world features on the earth's surface. The information on a typical line map is obtained from land survey field measurements or from aerial photographs using a geodetic control network to establish the accurate location of key points and physical features. Line maps, similar to the one shown in Figure 31, may include 2-dimensional (planimetric) natural and manmade features, such as rivers, streams, forests, roadways, sidewalks, buildings, manholes, fencelines, and the like. Or, the information may also include, at an additional cost, 3-dimensional elevation features known as contour lines (topographic maps).

Most municipal base maps are derived from aerial photographs. Aerial photographs record everything along the aircraft's flight line, so the photographs are saturated with information. This is both an advantage and a disadvantage for map users. If users are inexperienced in the interpretation of map information, they might have some difficulty interpreting what they see, especially if features are obscured by ground cover or if the features are too small to identify.

Also, an aerial photograph is a perspective view that shows both the tops and bottoms of such features as buildings, trees, and telephone poles. Because it is a perspective view, the scale is not constant; the higher ground is closer to the camera lens than the lower elevation areas. To correct this problem, aerial photographs must be processed through a stereoplotter to produce an orthographically correct base map. The result is a base map with a view that is exactly perpendicular to the drawing surface at every point.

Orthophotomaps

Orthophotomaps are also derived from aerial photographs. Orthophotomaps are created by assembling several orthophotographs into a single composite picture called a mosaic. Orthophotographs are photographs on which displacements of points caused by tilt, relief and perspective have been removed so features are in their true orthographic position and the scale is constant throughout the photograph (see Figure 32).

Figure 32. Orthophotomap

Satellite Imagery Maps

Satellite imagery maps (see Figure 33) are created from data collected electronically by earth-orbiting satellites and transmitted to receiving stations on earth. Because objects on the earth's surface reflect varying amounts of energy (light) in different parts of the electromagnetic spectrum, satellite sensors can detect and record groups of objects.

Although the maps created using this technology are interesting and useful for many purposes, such as mapping natural resources, they lack the detail and rigid spatial framework required of a municipality's primary base map.

All the maps we've described thus far can be produced in paper form (analog), as plots or photographic prints or in digital form. While the first two map types continue to be useful, it is the digital base map that is most versatile because it is dynamic and easily updated as new data are added to a community's GIS. This is an impor-

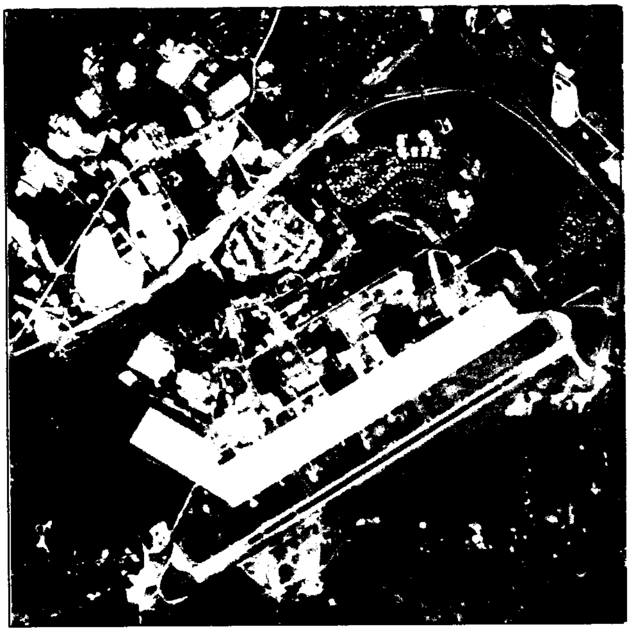


Figure 33. Satellite Image

tant capability for communities to consider when implementing a GIS.

The data used to create a digital base map may be derived from several sources, such as existing line maps that have been digitized, aerial photographs that have been photogrammetrically connected, or surveys that have been performed. The data are then entered into the computer, stored, and accessed, as needed.

The digital nature of the data allows users to easily merge data from many sources and produce accurate multi-purpose images quickly, efficiently, and cost effectively. However, to avoid attributing unwarranted accuracy to paper maps produced from digital data, users must know the origin and scale of the data used to create the base map.

Some General Considerations About Maps

The following sections discuss some key concepts involved in mapping.

What Are Map Projections?

Maps are graphical representations of natural and manmade features on the earth's surface. A Map Projection is used to transform these features onto a flat map surface. Because a map is a scaled-down representation of a large, irregular surface, the selection of a map projection is always a compromise.

Unfortunately, no map projection can depict area, shape and direction together without some distortion. Only a globe can do this. There are two general classes of map projections commonly used: Equal Area projections and Conformal projections. Each is described below.

Equal Area Projections retain the proper size of areas, but in so doing, distort the shapes of areas. Also, map scale is variable, and distance and angles are distorted throughout the map.

Conformal Projections preserve the correct scale in all directions at any given point, and thus the shape of features is preserved. Even though the area of features might be distorted, correct distances and angular measurements may be made.

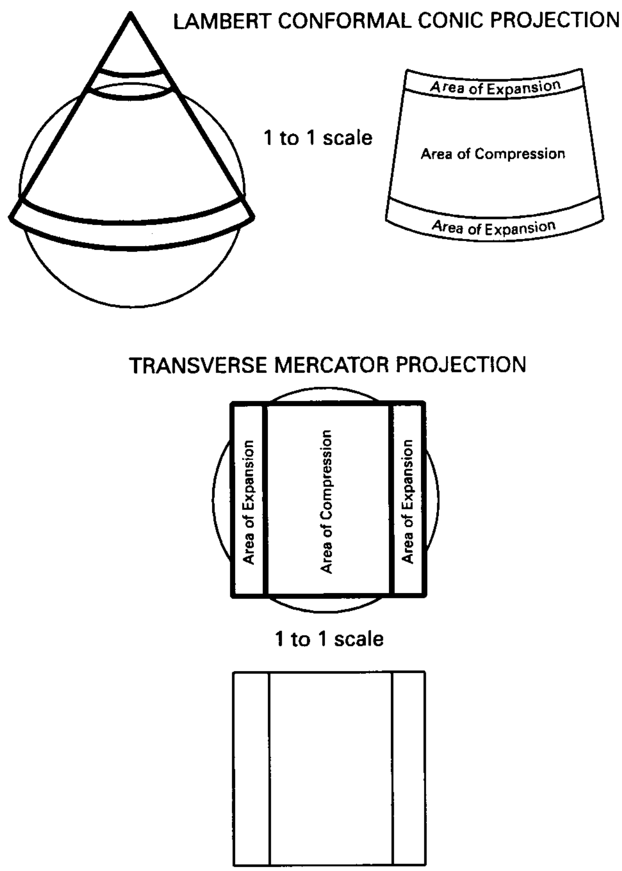


Figure 34. Map Projection

The accepted map projection for the State of New Hampshire is the Transverse Mercator Projection, a conformal projection ideally suited for mapping states like New Hampshire, Maine and Vermont, which are longer in the north-south direction than they are in the east-west direction. At larger scales, such as used by a municipality, the amount of areal distortion in a conformal projection is minimal.

Coordinate Systems

Coordinate systems provide a framework for mapmakers to use in assigning numeric values to locations on the earth's surface. With this framework in place, features can be positioned on a map. The appropriate coordinate system to use for a particular 2- or 3-dimensional map is related to the size of area to be mapped.

Geographic Coordinates, sometimes referred to as the Latitude/Longitude Coordinate System, divide the earth very much like a compass divides a circle.

The Equator is the zero degree latitude circle that divides the earth into a Southern and Northern Hemisphere. The North and South Poles are the 90 degree points of latitude. Between the Equator and the Poles are parallel lines of latitude circling the earth. This system of parallel lines allows mapmakers to assign a north-south coordinate to any intermediate point.

Lines of longitude run from Pole to Pole, and intersect latitude lines at 90 degree angles. The prime line of longitude, called the Prime Meridian, runs through the Royal Observatory in Greenwich, England. All other lines are either east or west of it. Longitude lines provide us with a reference to assign east-west coordinates to any point. (See figure 35).

The Geographic Coordinate system is especially useful for mapping the earth and large land masses. Mapping smaller areas, such as a town, is most easily accomplished with a system of plane coordinates similar to a sheet of graph paper. The system used in New Hampshire to compute the x and y coordinates of a location is the New Hampshire State Plane Coordinate System of 1983 (NHSPCS83). This system is mathematically related to the global system of latitude

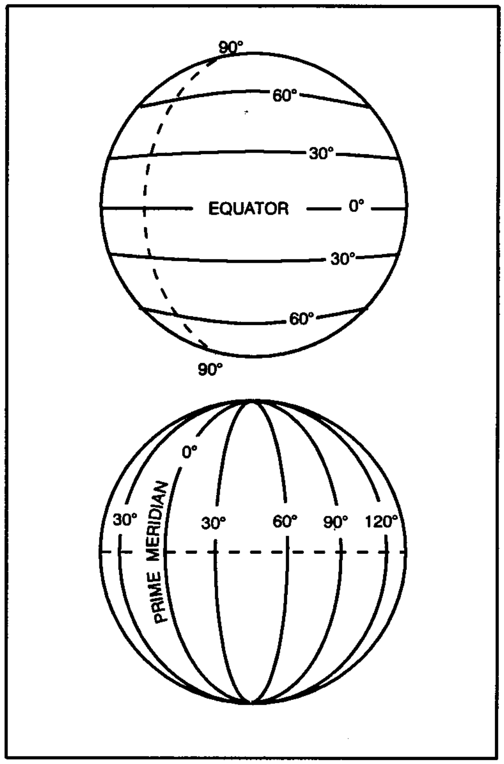


Figure 35. Latitude and Longitude

and longitude through the Transverse Mercator map projection. In the NHSPCS83, coordinate values may be expressed in either meters or U.S. Survey Feet (1 meter = 3.2808333 feet).

By law, all mapping in New Hampshire must be based on the NHSPCS83. This requirement ensures that all maps produced by municipalities and state/federal agencies are compatible.

Map Scale and Resolution

One of the most important conventions used on maps is map scale, which is the ratio of an object's length on a map compared to its actual length on the earth's surface. There are three ways to express map scale:

- ***Miles or Feet-Per-Inch-Scale.*** This scale specifies the number of feet or miles a one-inch line on a map represents, such as 1" = 100' or 1 inch equals 100 miles.
- ***Graphic Scale.*** This scale uses a graduated line to represent the actual number of miles or kilometers shown on a map. The value of this scale is that it remains accurate even after a map has been enlarged or

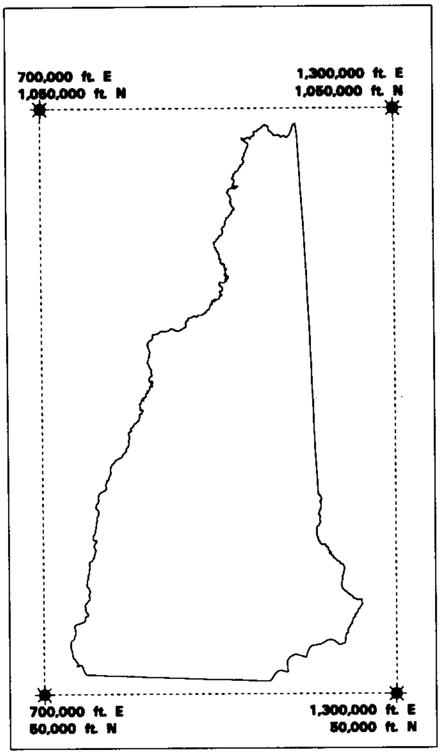
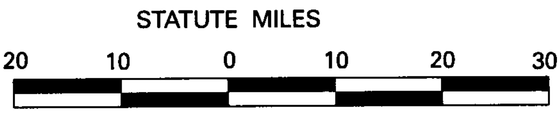


Figure 36. State Plane Coordinate System

reduced in scale. Typically, this scale is shown in the following form:



- ***Representative Fraction.*** Expressing scale as a representative fraction is commonly used. Scale is expressed as, for example, 1:1,000, where 1 inch on the map equals 1,000 inches or about 83 feet on the ground (1000/12).

Usually, maps are drawn to a specific scale. When they are not, they should be marked as "Not to Scale" to caution the user.

Map scales are often described as "large" or "small". Typically, large-scale refers to maps at scales of 1:4,800 or greater. Yet, these terms are relative, in that scale refers to the size of the features shown and not to the size of the physical map sheet.

Large-scale maps show objects larger than they would appear on a small-scale map, resulting in a more detailed feature representation (or increased map resolution). Since the features are shown larger, more (or physically larger) map sheets are required to represent the same areas on a large-scale map as on a smaller scale map. And because more detail is commonly presented, more data are required to develop the maps and more aerial photographs are required to provide the data. Mapping at larger scales offers many benefits to the community, but must be evaluated in the context of the increased costs.

Map Accuracy

The accuracy required of a particular map depends upon the proposed use of that document. For example, a road map need only depict the relative locations of significant towns, roads, intersections, and other points of interest. It is only important that features be shown accurately relative to one another. A clear sense of where you are going is more important than absolute accuracy. On the other hand, a map depicting the locations of utilities or property boundaries requires very high absolute accuracy at a large scale.

Generally, map accuracies are determined by comparing the mapped position of a feature against its true position on the ground. There are two sets of map accuracy standards that mapmakers use:

- ***U.S. National Map Accuracy Standards (USNMAS),*** which cover both horizontal and vertical accuracy for smaller scale maps (see Appendix 5 for details of these standards).
- ***American Society for Photogrammetry and Remote Sensing (ASPRS) Interim Standards for Large-Scale Maps,*** which cover both horizontal and vertical accuracy for larger scale maps (see Appendix 6 for details).

Regardless of which set of standards is used to produce a map, there are certain constants related to accuracy which hold true:

- Mapped data can never be more accurate than the accuracy at which they were collected. For example, a soils map plotted in the field on a 1 inch = 800 feet scale, and enlarged to the scale of 1 inch = 100 feet does not provide more reliable information on which to base decisions.
- Given a base map compiled at a scale of 1 inch = 100 feet with fire hydrants plotted with an accuracy of plus or minus 50 feet, the hydrants may appear on the wrong side of roads or houses.

Being attentive to map scales and data accuracies will help you avoid cluttering your map system with misleading and inappropriate data.

Map Design Considerations

Maps are useful when they contain the information users need and are designed to help them find the information easily. Therefore, care must be taken when selecting the map elements that will be most useful to meet your community's needs. These elements include scale, accuracy, map projection, legend, sources, colors, symbols, and subject matter.

Scale and accuracy are especially critical because they must be determined before a geodetic control network is established and before aerial photography takes place. Both map scale and accuracy provide the guidelines for the density and layout of the ground control network required for aerial photo control, flight line, and flight altitude. Scale and accuracy also guide the map producer in the selection of the stereo equipment used to compile the map.

Map design is an equally critical element to consider before undertaking any mapping. The features a map shows have a direct effect on the information they convey. The symbols used to depict features project a nuance or feel to the map user. For example, the size, color and position of a symbol reflect a level of importance whether or not it is intended. The mapmaker and user must be aware of this effect.

In addition, all maps involve some level of generalization of features. For example, a river may be shown as a single blue line or a power substation may be portrayed as a dot. Generalization is necessary to improve the appearance and legibility of the map. The degree of generalization required will be determined by the area and scale of the map. Maps of larger areas must contain greater generalization than maps of smaller areas, given the same size map sheet. Therefore, there is a trade-off between showing increased detail and widespread generalization of a larger area.

Base Map Contents

The base map in a GIS must contain several types of basic information upon which a reference framework is built. The framework must be familiar and constant, so that all users from many disciplines can relate their specific interests to it. From a community's point of view, the political boundaries are a natural limiting factor for its maps. Features, such as lakes, streams, rivers, hills, valleys and roads provide reasonably clear divisions within communities. Finally, the geodetic control network within the municipality provides the precise coordinate base that connects all other features together into a coherent system.

The Layered Database

An operational GIS divides data of similar topics into layers. Hard-copy map sheets of these individual data layers are called separates. So that the separates can be used in conjunction with each other, mapmakers use a registration system. In a layered database, the base map and the geodetic control network jointly create the spatial framework, which allows the user to relate all layers to each other. (See Figure 39.)

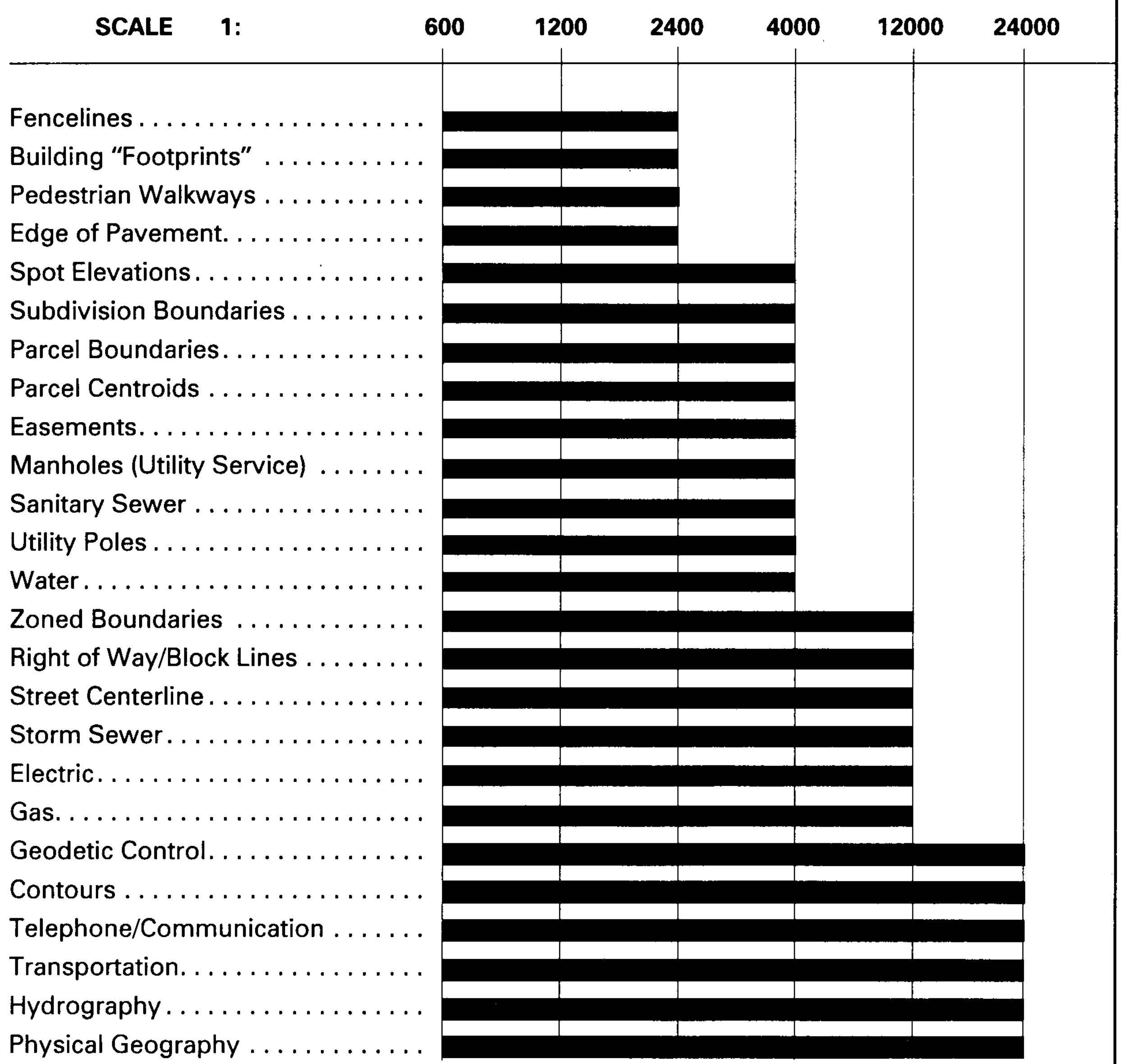
Local geographic information systems based on hard-copy maps are commonly split into six map separates, as follows:

- ***Base Map Features:*** Transportation, including streets and railroads; hydrography, including bodies of water; political boundaries; topography (surface elevation data), including contour lines and spot elevations;

- ***Cadastral:*** Property lines, rights of way, easements, lot and block data, and addresses;
- ***Infrastructure:*** Surface and underground service and utility lines, buildings;
- ***Natural Features:*** Soil units, wetlands, aquifers;
- ***Administrative Districts:*** School, ward, zoning.

Figure 37 depicts scale ranges which are appropriate for showing various map features. Due to the speed and power of computers and software, an automated digital map system can manage many more data layers than a system of hard copies of map sheets.

Figure 37. Scale Ranges for Depicting Certain Map Features



Typical scale ranges for depiction of certain map features

Using Aerial Photographs to Prepare Base Maps

Following your community's initial decision to implement a GIS, you must consider carefully the source of the base map. There are three options available to you:

- Buy an existing digital base map from a vendor, such as a mapping firm, the NH GRANIT System, or a regional planning commission;
- Buy an existing hard-copy base map and digitize it; or
- Create a new base map based on new photogrammetry.

Each option has its advantages and disadvantages. For example, finding a digital map of your community at an appropriate scale may be difficult. Digitizing an existing map, such as U.S. Geological Survey (USGS) maps or existing tax maps, is fast and inexpensive.

However, if the scale of the source map is not appropriate, digitizing the map will merely create a computerized product that is also inappropriate for your applications.

Creating a base map on previously flown or new aerial photography (i.e., photogrammetry) might be a better choice, although it has its limitations. Aerial photography records the earth's surface at the instant film is exposed. Consequently, the information an aerial photograph records is out of date as soon as it is taken. Manmade features, such as roads, bridges or buildings added after the aerial photographs were obtained will not be included. However, you can keep track of additions and modifications to the built environment in a separate system, manual or digital, so long as proper documentation is maintained regarding the date of photo acquisition and the date of all subsequent alternations.

Contracting for new aerial photography provides the opportunity to make many critical decisions before the flyover, such as establishing and targeting a geodetic control network, and specifying the base map's scale, which will determine the height at which the aerial photography is taken and, ultimately, the accuracy of the base map.

There is a theme that winds itself through the entire GIS implementation process:

Know the Origin of Your Source Data!

This is as true for the source data as it is for the aerial photography, base map and any future additions to the database after a GIS is operational.

Geodetic Control

An accurately established geodetic control network provides the basic spatial framework needed to develop an accurate and reliable mapping system. A GIS that is built on an accurate geodetic network contains an easily accessible system with which to interrelate land features. The network also allows users to correlate data layers within a GIS, as well as with other compatible GISs in other communities throughout the State.

A permanent geodetic control network consists of the following components:

- Permanently marked and stable points, known as monuments or points, which are used to register, scale and control aerial photography, and to support future surveying, mapping, engineering, construction, and resource management projects.
- Descriptive text and field measurements to ensure accuracy and to facilitate the recovery of the monuments.
- Specific density of monuments and a datum (discussed below) to mathematically relate the network to the earth.

An important question one has to answer is whether or not a permanent geodetic control network is needed. Geodetic control is necessary for managing a community's utilities, positioning property lines or for engineering design. However, if the GIS is based on existing maps, and is designed to provide a generalized view of the community, a control network might not be necessary.

Although adding geodetic control to an existing GIS is possible, the data collected before the network is established will not have the same accuracy as the new data. Updating the older

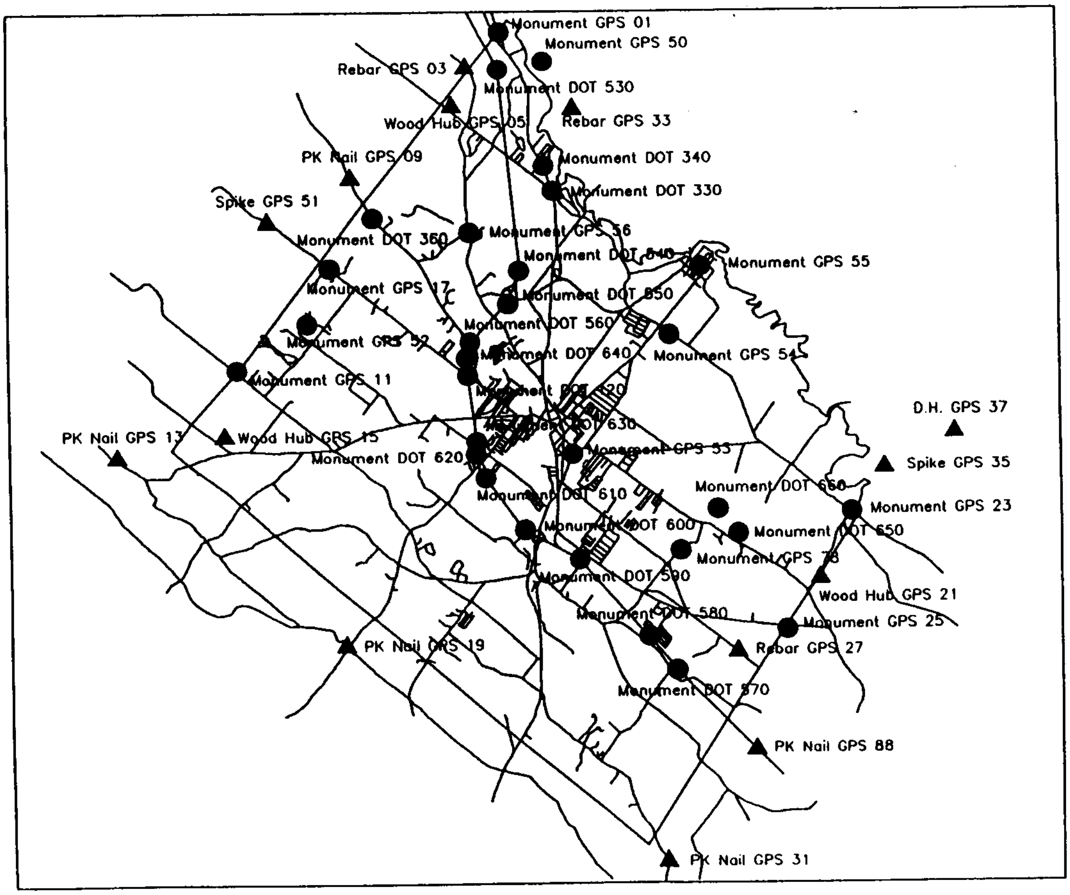


Figure 38. Geodetic Control Network

data to the new accuracy standards requires additional effort and money. Until recently, establishing an accurate geodetic control network has been costly and difficult. The use of Global Positioning System (GPS) surveying, and the increased availability of known control points, has made the use of precise geodetic control more cost effective and less difficult.

Horizontal and Vertical Datums

The earth's surface is highly irregular, a physical characteristic that does not lend itself to simple mathematical definition. However, mapmakers have developed mathematical models, called Geodetic Datums, to relate surveys and maps to the earth's surface, as follows:

- ***The North American Datum of 1927 (NAD27)*** was the horizontal datum used from the 1930s until the mid-1980s. It was found to be too imprecise for use with modern techniques, such as satellite surveying techniques.
- ***The North American Datum of 1983 (NAD83)*** is the current horizontal datum used by surveyors and mapmakers, and is designed to work with satellite positioning systems. New Hampshire officially adopted the NAD83 and is the only datum to be used as of January 1, 1990.
- ***The National Geodetic Vertical Datum of1929 (NGVD29)*** was based on mean sea level at several tide gauges in the United States and Canada. As with the NAD27, this vertical datum has proved inaccurate and was replaced with a more reliable, accurate datum.
- ***The North American Vertical Datum of 1988 (NAVD88)*** is the current vertical datum used by surveyors and mapmakers. It is more accurate and reliable than the NGVD29, because it removes the distor-

tions created by the difference in mean sea level, or geoid, from one area to another. Federal mandates require that all new flood plain mapping projects use the NGVD88.

The State Plane Coordinate System

The New Hampshire State Plane Coordinate System of 1983 (NHSPCS83) is represented on the ground by a statewide network of monumented control points. These control points are connected to the much larger and wider ranging National Geodetic Reference System (NGRS). All control surveys undertaken in New Hampshire must begin at NGRS stations. This ensures that the stations within a community's GIS are related to all other control points in the State and in the nation.

Data relating to the approximately 6000 control points in New Hampshire are available from the Survey Section of the New Hampshire Department of Transportation (NHDOT); provides NAD83 coordinate data on stations and NGCD29 and NGVD88 elevation data in its database.

Methods of Establishing Control

Horizontal Control

The classical methods used to establish horizontal control have changed very little since the 1800s, when the nation's National Geodetic Reference System was established. Through the use of classical instruments, surveyors have been able to accurately measure precise angles and distances.

The development of the Global Positioning System (GPS), which uses a constellation of 24 earth-orbiting satellites, has improved our ability to position points to incredible levels of accuracy.

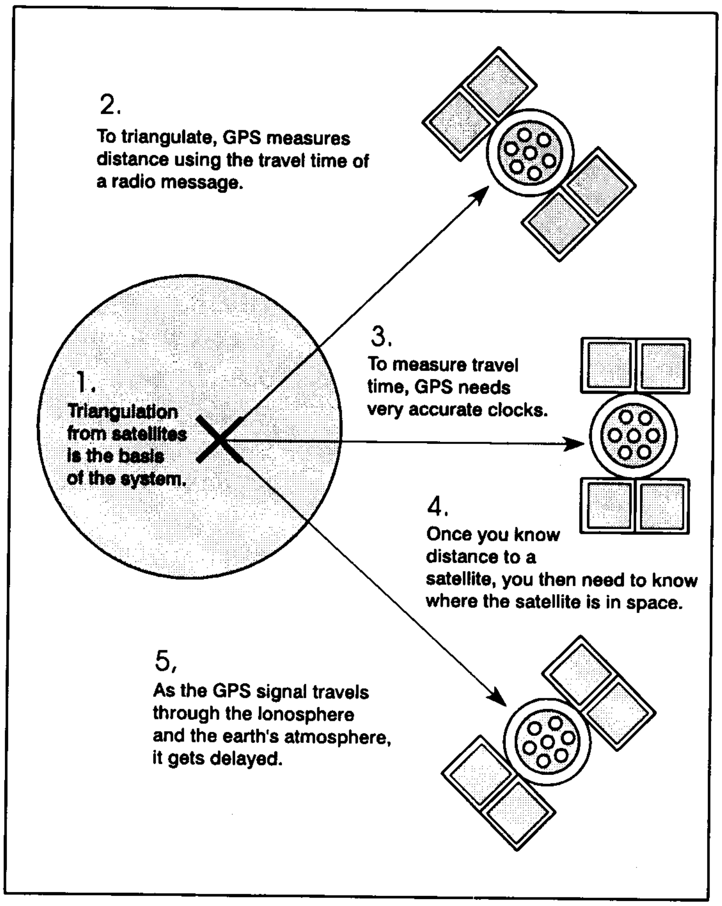


Figure 39. GPS Diagram

Whereas classical surveying techniques require that a point be visible to all other points, such as a mountain top, the GPS requires only that the receiving equipment have a clear view of the sky. Consequently, points can be located in easily accessible areas. This capability is a major factor for lowering the cost of large-scale, wide-area mapping projects, such as mapping towns and cities.

Vertical Control

There are three methods for establishing accurate elevations:

- Differential leveling using conventional surveying equipment and techniques
- Mathematical models used in conjunction with GPS measurements
- Trigonometric leveling using conventional surveying equipment

Differential leveling is still the most precise and accurate method for establishing accurate elevations, which are related to the mean sea level or geoid. Although GPS observations provide precise measurements of a point's distance from the center of the earth, they do not provide precise measurements related to the geoid.

By using mathematical models of the geoid's shape, we are able to estimate an elevation at a given location. These models, used in conjunction with GPS measurements, provide us with acceptable elevations for many mapping projects. Differential leveling, however, still provides a greater degree of accuracy.

Trigonometric leveling is a third method for determining elevations. This method uses conventional surveying equipment to measure vertical angles and distances, and to compute elevation differences between points. As with mathematical models, this method provides acceptable elevations for most surveying projects. How-

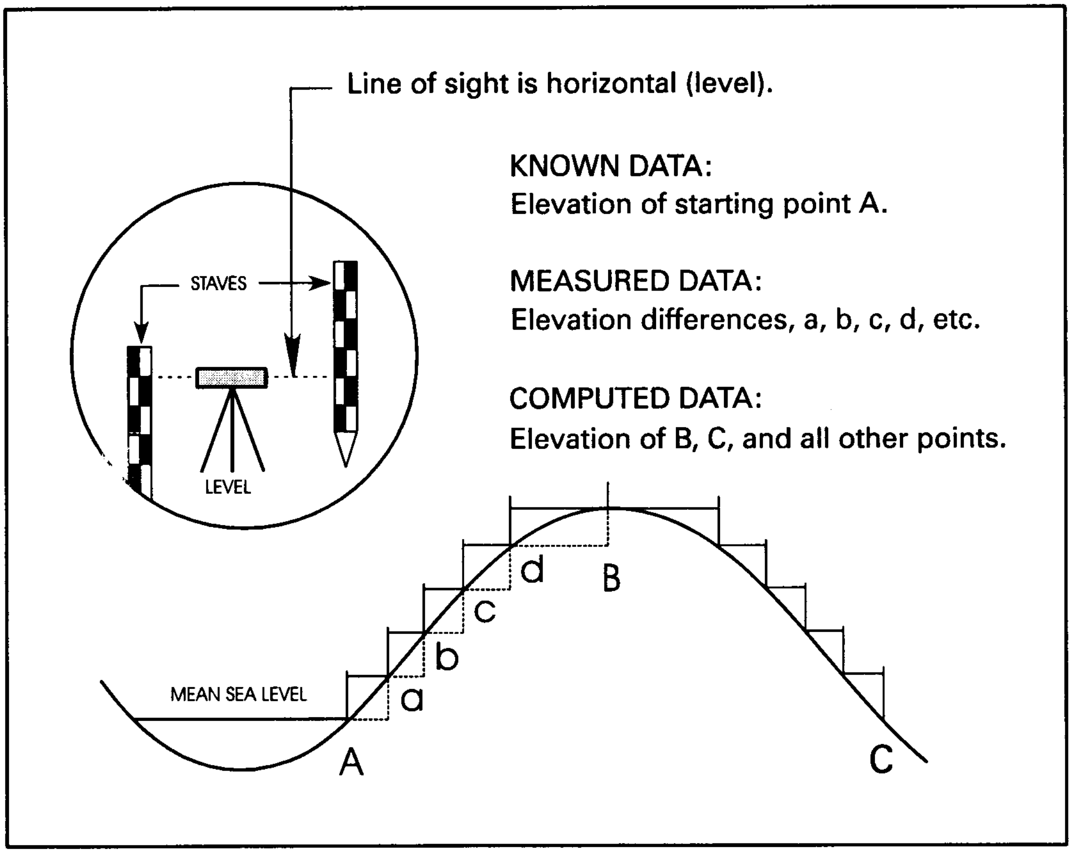


Figure 40. Differential Leveling

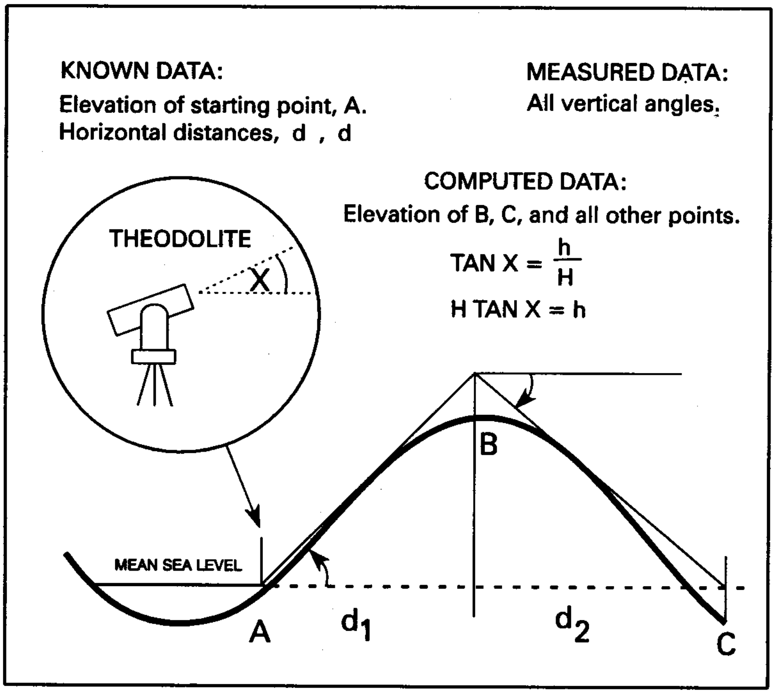


Figure 41. Trigonometric Leveling

ever, it is not recommended for determining precise elevations.

Monumentation

Permanent monumentation is a major component of a geodetic control network. Many types of monuments can be used to establish a stable and secure control network, including:

- Rock outcroppings
- Large boulders
- Cut granite posts
- Large manmade structures, such as dams

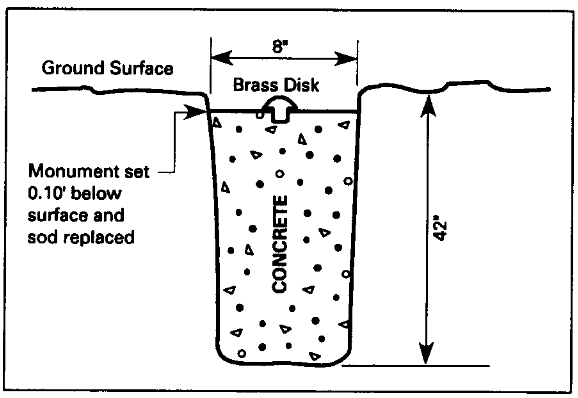


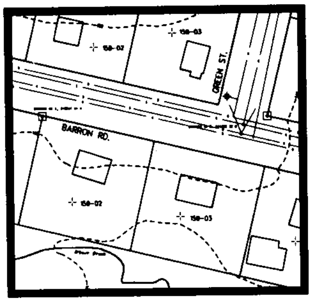
Figure 42. Monument

Each control monument should be capped with a metal disc, usually of brass. When setting a monument, the depth of frost penetration and soil types should be considered. Frost heaves will dislodge even the heaviest of monuments.

Another consideration is the protection and maintenance of the monuments. Natural and building activity attack any monument over the course of time. A good strategy to limit the destructive impact of natural and human forces is to set new marks out of the path of construction and in inconspicuous sites. The monuments should be inspected periodically.

Summary

An up-to-date GIS based on base mapping and an accurate geodetic control network created under the supervision of a licensed land surveyor will provide a powerful tool for management of a community's resources. With a little planning, the GIS will serve a municipality's mapping, engineering and surveying needs well into the future.



Chapter 8.

Future Directions

Introduction

As stated in the Preface of this guidebook, the future of GIS technology for local government is bright. As software and hardware prices continue to decrease and system sophistication increases, GIS is likely to become an integral part of municipal management and decision-making. In addition, as the need for comprehensive spatial data grows, the uses of GIS will be limited only by the imagination of GIS users.

Roles for the State in Support of Municipal GIS Efforts

In addition to this guidebook and several planned technical bulletins, which provide information to local officials, there are other avenues by which the State can assist municipalities with their GIS programs. The following have been proposed as potential assistance activities:

Municipal GIS Advisory Group. There is already a New Hampshire State GIS Advisory Committee, which meets every other month to discuss problems and opportunities of interest and to coordinate related projects and activities. A similar group could be established to consult on problems facing towns and cities, and to work with the State to recommend initiatives and solutions. The regional planning agencies could play a key role in this activity.

Annual Municipal GIS Workshop. The Office of State Planning (OSP) has conducted several GIS workshops and conferences devoted to the interests of local government. These have been well attended and have indicated a continuing level of interest. Subject to the availability of resources, OSP could host an annual conference to address municipal GIS concerns.

GIS Bulletin Board. An electronic bulletin board is another idea for providing municipal GIS assistance. This board would be available to communities interested in obtaining timely information about vendors, tips on specific GIS software and computer hardware and related topics. Such a bulletin board would also provide a means for municipalities to communicate with one another on matters of mutual concern. This initiative requires a small investment to start, although it would require continuing technical support and funding in order to provide meaningful information exchange to users who access it.

Digital Orthophotography. Recently, a number of states have undertaken programs to produce large-scale digital orthophotography for use as a controlled map base for geographic information systems by state and local governments. Vermont, Massachusetts and Connecticut are working on 1:5,000-scale digital orthophoto data programs. At this scale, base mapping data derived from such digital orthophotographs would be adequate for many local needs, particularly in rural towns and less-developed portions of larger communities. The cost of implementing a program to develop 1:5,000 digital orthophotography for New Hampshire is on the order of $2,000,000. In 1995, 1:12,000-scale digital orthophotography will be available for Rockingham County from the U.S. Geological Survey (USGS). While at a smaller scale than that mentioned above, the USGS orthophotography will provide an opportunity to evaluate digital orthophotography and its application to the local government level. The cost of implementing digital orthophotography at the scale 1:12,000 for the remainder of the State will cost about $150,000, assuming a 50-50 cooperative arrangement with the USGS.

Town and City Boundaries. Another action for the State to consider is improving New Hampshire's municipal boundary coordinate information. As towns and cities develop large-scale base maps tied to ground control, the accuracy of their jurisdictional boundaries becomes a matter of concern. Accurate political boundaries provide a framework within which municipalities construct their large-scale base maps. Inaccurate boundaries could result in land areas not being included in any town, or in land area being claimed by abutting municipalities in their mapping. Having accurate boundaries would be important when attempts are made to join several municipal base maps into a regional map.

One suggestion is for the State to develop specifications for communities to use when they have base maps prepared so that coordinates for boundary monuments or markers are accurately determined. Use of Global Positioning System (GPS) technology can make the surveying of remote bounds affordable.

Another suggestion is for the State to assume a more aggressive stance by providing direct assistance to communities interested in surveying their bounds. This approach could involve hiring a technician and GPS unit to conduct, with local officials, a field survey of boundaries. Ultimately, to complete such a program, disputed or less undertermined municipal boundary segments must be addressed and resolved. The NH Department of Transportation has identified at least 20 boundaries that fit this description.

Technical Bulletins

To assist local officials as they consider a GIS for their municipality, the Office of State Planning will publish and distribute a series of technical bulletins, each of which will deal with a specific aspect of geographic information systems. Currently planned are the following bulletins:

Model Municipal GIS Data Standards and Specifications. Well-defined data standards and specifications are important for creating a comprehensive GIS database. Not only do they determine the quality, accuracy and consistency of the spatial data, but they also promote effective data management and high-quality documentation.

Therefore, this bulletin will provide guidelines for defining GIS data and documentation standards and specifications.

Legal Issues. This bulletin will discuss the often confusing legal issues surrounding access to and ownership of the State and municipal spatial data. Additionally, the bulletin will discuss the issue of privacy of computerized public records, sale of data, and custodial requirements.

Model Ordinances Requiring Digital Data. As municipalities develop GIS and digital mapping capabilities, it is necessary to continue adding new data. One method for accomplishing this at minimal cost to the public is for the community to require applicants to submit digital data on projects as part of the permitting approval process.

As currently planned, this bulletin will present standards, specifications and procedures for submitting such digital data.

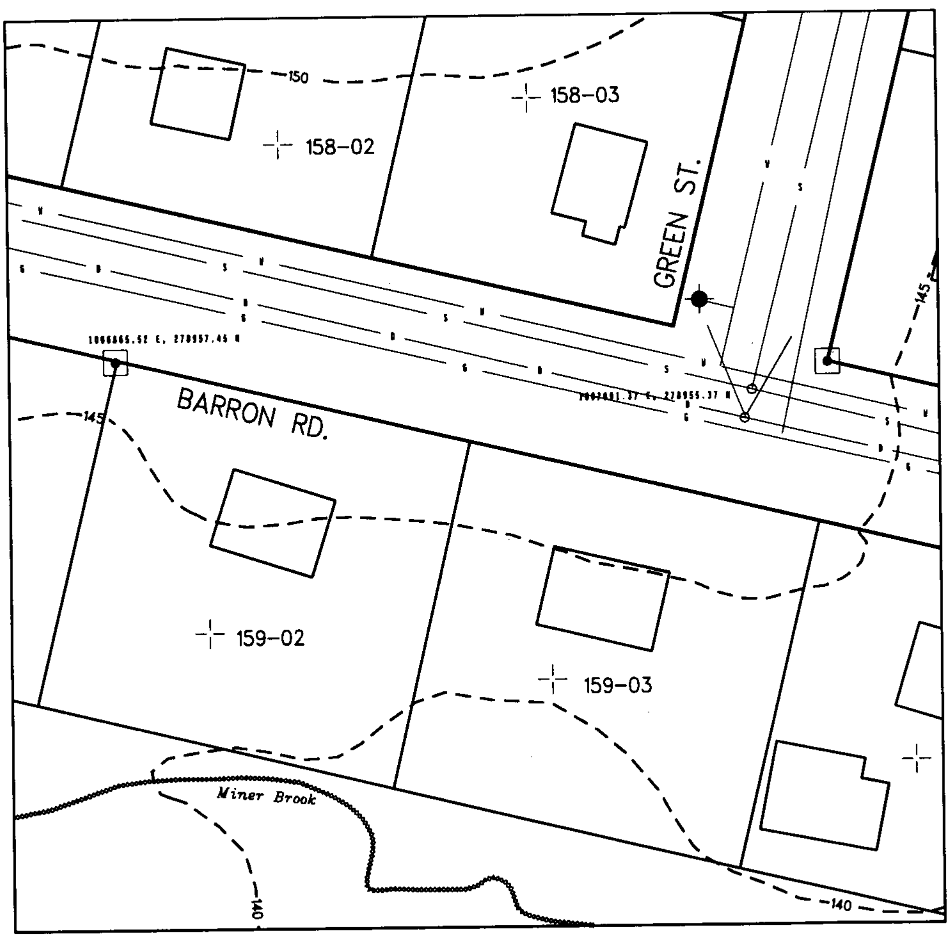
Model Base Mapping Specifications and Model Request for Proposal. All geographic information systems begin with mapping, whether in converting paper maps to digital format, or developing new mapping derived from aerial photography. The latter approach will be discussed in detail and will cover specifications for establishing a geodetic control network, planning and obtaining aerial photography and orthophotography, and other specifications for building a comprehensive, accurate base map to be added to the GIS's central database.

In addition, this bulletin will include a model request for proposal (RFP) that municipalities may modify and use when buying base mapping services. This RFP will be comprehensive, covering all aspects of what a municipality should include in an RFP in order to select a vendor who will provide the best services/products at a price the town or city can afford.

Sample Municipal Database Design. Designing a database that meets the specific needs of a municipality is a critical and costly activity that cannot be ignored. To assist local officials with this task, this bulletin will present guidelines for structuring the graphic and non-graphic data so that map features, their relationships, and characteristics can be easily retrieved and displayed. Items to be covered will include methods for preparing the source materials, entering the data, and applying quality control standards.

Summary

This guidebook is the result of more than a year of intensive effort by the authors and contributors listed in the Acknowledgements. Rather than being a finished product, this guidebook should be viewed as a dynamic document, which will be updated as circumstances warrant. Suggestions and recommendations for improving this guidebook are requested and welcomed by the Office of State Planning.



Appendix 1
Glossary of GIS Terms

32-Bit vs. 16-Bit vs. 8-Bit: The width of the data path used in the bus technology (see **bus technology**). Wider data paths allow for faster transfer of data within the computer system and result in higher performance computers.

Absolute Map Accuracy: The degree to which objects on a map are positioned at their true ground locations relative to a coordinate system, such as geographic coordinates (latitude and longitude) or State Plane Coordinate (x,y) (see **Relative Map Accuracy**).

Aerial Photography: Photographs of a part of the earth's surface taken by a camera mounted in an aircraft for mapping purposes. This usually consists of a series of overlapping vertical photos taken in strips which can form the basis for mapping.

Application Program: A program or piece of software that performs a task for the user, such as a spreadsheet program. This is compared to programs that run to perform a task for the computer, such as the operating system software.

Attribute: Alphanumeric (non-graphic) data related to a specific map feature (point, line or polygon). For example, parcel information linked to a specific parcel (polygon) might include the parcel owner's name and the parcel address.

Base Data: Basic level of data or features on a base map.

Base Map: A term which varies in different applications, but, in general, refers to a map that depicts the fundamental map elements, such as streets, buildings, streams, etc., which are used frequently for locational reference. It is the control document from which various other maps in a geographic information system are developed.

Boundary Survey: A product of licensed land surveyors, which depicts the property lines and corner monuments of a parcel of land relative to its abutters or neighboring properties.Sometimes referred to as a **boundary plat**.

Bus Technology: The type of technology used for interconnecting internal computer system components, such as the CPU and internal hard drives.

Cache Memory: Frequently used data and programs are stored in this temporary memory. Before executing a command, the CPU accesses this memory first for instructions or data.

CAD (or CADD): Acronym for Computer Aided Drafting (and Design). CAD describes software that is used to create 2- and 3-dimensional graphic elements in a computer system. Certain CAD software also allow some attribute processing, analysis, and calculation. Recent advances in CAD include modeling and animation capabilities.

Cadastre: A system that defines the legal characteristics of properties, such as ownership, title issues, value, etc.

CD-ROM (Compact Disc-Read Only Media): A removable flat circular disc (as used in the music industry) that is read using a laser optical reading device. Information is not written to this type of disc except when it is initially created. Typical storage capacity is 300 to 600 megabytes.

Central Processing Unit (CPU): A computer's main processor that is responsible for executing instructions, such as those necessary to run software.

Conformal Projection: One type of flat map which depicts figures transformed from the surface of a sphere in their original forms (shapes). There is no one type of map projection that can "project" figures from a sphere onto a flat surface without distortions in either shape or size (see **Equal Area Projection**).

Coordinate Systems: A framework used to define the positions (locations) of points in space either in two or three dimensions. Examples of such systems would be a spherical system, such as latitude and longitude, or a planar system, such as State Plane Coordinates (x,y).

Coverages: One of a series of data themes, such as wetlands or water lines, in a geographic information system with graphic and attribute data related to that topic.

Database Management System (DBMS): A systematic approach to creating, maintaining, accessing, reporting, and analyzing attribute (alphanumeric or text) data.

Data Dictionary: A directory of all data items in a GIS. It does not contain the actual data items, but information on the types, names and structures of the data items. It is data about the data.

Datum: In mapping, a numeric or geometric quantity which serves as a reference or base to accurately define other quantities. It most often refers to either a horizontal standard, such as a particular spheroid for referencing coordinte positions, or it refers to a vertical datum, such as mean sea level, from which elevations are referenced

Desktop Mapping: The ability, with modern personal computer hardware and software, to produce a variety of mapping and spatial analysis products at one location. The ability to graphically manage, analyze, and present or view data.

Desktop Publishing: The ability, with modern personal computer hardware and software, to produce a variety of publisher-quality documents, reports, etc.

Differential Leveling: The process of measuring the difference in elevation between any two points by use of a spirit level (closed glass tube) or the newer automatic level (pendulum) to maintain horizontal line of sight.

Digital Map: A computer-readable representation of a geographic area or phenomenon that can be displayed or analyzed by a digital computer. This is in contrast to an analog "paper" map.

Digitizing: A method of converting map data that is in analog form (paper or hard copy) into digital data usable by a computer (see **Scanning**).

Download: A term used to describe transferring digital data or information from a source, such as digital tape, to another location, such as a hard disk.

Equal Area Projection: A type of map projection which maintains figures areas but not their original shapes (see **Conformal Projection** and **Projection**).

Fiber Optic: Media based on fiber optic cables, used in communication systems and networks, that is capable of transmitting data at the highest speed possible.

Field (Item): A single attribute descriptor or characteristic of a feature. Commonly displayed as a column in an attribute table, such as a last name. This is in contrast to a record or row (see **Record**).

File Server: A computer that is configured to share the data on its disks with other computers across a network. A file server often has software and application programs installed on its disks that other computers access to run that software.

Floppy Drive: A device that accepts a removable disk, called a floppy disk, and reads or writes data to the disk. Floppy disks are enclosed inside a protective cover which is either 3½" or 5¼" square. Capacities of floppy drives and floppy disks can vary, but range from 320 kilobytes to 2.2 megabytes.

Geodetic Control: A system of horizontal and/or vertical stations tied into horizontal and/or vertical datums, which are established to facilitate the location of other features on, above or below the earth's surface (see **Datum**).

Geographic Information System (GIS): An organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information. Certain complex spatial operations are possible with a GIS that would be very difficult, time-consuming or impractical otherwise.

Geoid: The figure of the earth considered as a sea level surface extended continuously through the continents. It is a theoretically continuous surface that is perpendicular at every point to the direction of gravity (the plumb line) (see **Datum**).

Global Positioning System (GPS): A constellation of satellites originally developed by the U.S. Department of Defense as a navigation aid. It is now used by the civilian community for navigation and horizontal/vertical positioning of features.

Graphic Database: A collection of digital descriptions of map features (points, lines/arcs, areas/polygons, pixels/grid cells), symbols and annotations which can be used to generate a display. This is in contrast to an attribute database (see **Attribute**).

Grid Cell: One of a network of regions enclosed by uniformly spaced horizontal and vertical lines which has an associated value assigned to it (see **Pixel** and **Raster**).

Hard Drive: A device which holds a fixed disk residing permanently inside the hard drive. The disk is a flat circular plate with a magnetic coating on which data are stored magnetically in concentric circles and can vary in size (width, height and length) and capacity. The size of the disk is often referred to as its **form factor**. The capacity of hard drives varies greatly, from 20 megabytes to 3.5 gigabytes.

Hardware: A general term for any of the physical (mechanical and electrical) components of a computer system, such as the CPU, keyboards, hard drives, floppy drives, or printers.

Horizontal Datum: The two most common spheroidal reference surfaces in the United States used as a reference or base to accurately define horizontal positions (x,y or longitude, latitude) are the North American Datum of 1927 (NAD27) or the more recent and precise North American Datum of 1983 (NAD83) (see **Datum**).

Hydrography: The representation of the location and direction of flow of water bodies. In geographic information systems, it usually refers to coverages depicting various water features.

Infrastructure: Human-made systems (or "built" systems) that provide any or all of the normal public services to an area. Infrastructure includes such things as roads and bridges, water supply systems and electric, gas or telephone utilities.

Latitude: The angular distance of a location north or south of the equator.

Layers: A logical separation of mapped data usually representing a theme, such as roads, political boundaries, etc. Layers are all registered to one another by means of a common coordinate system.

Line Map: A map that consists of points, lines and area symbols rather than continuous tone imagery.

Linking Fields: Used in a database management system to develop or connect various columns of data (items or fields) in the attribute database for review or analysis. For example, linking parcels over 50 acres in size with owner names.

Local Area Network (LAN): A communications system that connects computers within a limited geographic area, such as one building or group of buildings.

Longitude: The angle between the plane of a meridian and the plane of an initial meridian arbitrarily chosen (the Greenwich Prime Meridian). In the United States, this angle is commonly measured as the angle west of the Prime Meridian.

Map Accuracy: A measure of the maximum errors permitted in horizontal positions and elevations shown on maps. In the United States, the most common standards are the "American Society for Photogrammetry and Remote Sensing" (ASPRS) standards and the "American Society of Civil Engineers" (ASCE) standards.

Map Scale: The relationship existing between a distance on a map and the corresponding distance on the earth. A scale of 1 inch = 2000 feet can also be expressed as 1:24,000 (i.e., 1 inch on the map to 24,000 inches on the earth).

Map Separates: Map elements on different layers, either digitally or on some medium, each of which depict various types of information, such as roads, water surfaces, buildings, property lines, etc. Also known as **overlays** or **flaps**. Several separates may comprise one map.

Meridian: A "line" on the earth's surface which follows the shortest distance from pole to pole.

Monumentation: In surveying and mapping, this usually refers to physical objects on the earth's surface, the positions (x,y and/or z) of which are known or are established.

Mouse: A hand-held pointing device which allows a user to provide input to the computer by pointing at menu selections or by drawing as one would do with a pen. A mouse is typically palm-sized and contains up to three buttons.

Multimedia: In a geographic data context, the ability to reference and retrieve different forms of data, such as hard copy vector or raster maps, reports, tabular databases, photographs, audio records, video records, etc.

Municipal Information System (MIS): A type of GIS that focuses specifically on issues of concern to municipal governance.

Natural Features: In mapping, this term usually refers to features which are not human-made, such as streams, vegetation, geology, and topography.

Needs Assessment Survey: Sometimes referred to as a user needs or requirements analysis, this is a strategic planning tool for implementing a GIS. It provides a comprehensive assessment of the analytical capabilities and products required by potential system users.

Networks: High-speed communication systems for connecting computers, allowing users to share data and software from one computer to another.

New Hampshire State Plane Coordinate System: One of the plane-rectangular coordinate systems established by the Federal Government (one or more zones for each state), which is used for defining positions of points on, above or below the earth's surface in terms of x and y coordinates directly related to geographic (latitude and longitude) coordinates. Legally recognized in RSA.

North American Datum (NAD): There are two North American Datums: **North American Datum of 1927 (NAD 27)** and **North American Datum of 1983 (NAD 83)**. Both are geodetic reference systems, but each is based on different measurements. NAD 27 incorporated all horizontal geodetic surveys completed up to 1927. NAD 83 updated NAD 27 with current measurements using radio astronomy and satellite observations. NAD 83 positions are consistent with satellite location systems (see **GPS, Datum, Horizontal Datum**).

Operating System: The collection of software and firmware programs that make the computer system's hardware usable, allowing users access to storage devices, input and output devices, and allowing the running of application programs.

Orthophotography: An aerial photograph in which the distortions due to camera tilt and topographic relief have been removed. An orthophotograph has consistent scale throughout and can be used as a map.

Peripheral: An internal or external computer hardware device that provides the CPU with additional storage or functional capability. Disk drives, tape drives and printers are examples of peripherals.

Personal Computer: (PC) A general term for a class of computers that, typically, are average performance, single-user systems. Over the last dozen years, these computers have been IBM-PC compatible systems running the Microsoft Disk Operating System (MS-DOS).

Photogrammetry: The science or art of obtaining reliable measurements by photography. For GIS applications, aerial photogrammetry often provides the foundation to develop base maps.

Pixel : One picture element. Often used synonymously with a raster or grid cell. The smallest discrete element which makes up an image (see **Grid Cell** and **Raster**).

Planimetric: In mapping, refers to spatial data that do not include topographic or relief data.

Plotter: An electronic device used to produce output of spatial digital data on "hard copy" media (plots), such as paper or mylar.

Prime Meridian : The initial meridian or longitude 0 degree (Greenwich Meridian), which creates the plane from which an angle is measured to establish the longitude of a point (see **Longitude**).

Projection: A mathematical model that transforms the locations of features on the earth's surface onto a 2-dimensional map surface (see **Conformal Projection** and **Equal Area Projection**).

Query or Database Query: The retrieval and display of data from a database about one or more features, such as a parcel, its size, owner, value and location or address.

Random Access Memory (RAM): Computer memory that can be both read and written to, and can be accessed in a random fashion, as compared to a sequential fashion, such as tape access. This is the memory typically used to store the instructions necessary to run a software program.

Raster Data: One method of storing, representing or displaying spatial data in digital form. It consists of using cell data (not necessarily square) arranged in a regular grid pattern in which each unit (pixel or cell) within the grid is assigned an identifying value based on its characteristics (see **Vector**).

Record: In an attribute table this would consist of a single "row" of descriptors for one feature in contrast to an item or field or column which consists of a single attribute descriptor.

Relational Database: A database structure composed of more than one flat file (2-dimensional arrays) that can be transformed to form new combinations because of relations between the data in the records, in contrast to hierarchical and network database structures.

Relative: Map Accuracy The accuracy of map elements in relation to a local survey network that is not tied to the earth's geoid. The positions are accurate only within a certain geographic area covered by the local survey network (see **Absolute Map Accuracy**).

Resolution: A measure of the accuracy or detail of a graphic display expressed as dots per inch, pixels per line, line per millimeter, etc.

Satellite Imagery: Digital data obtained from sensors carried in satellites. It includes collecting data both in the visible and non-visible portions of the electromagnetic spectrum. One system is the multispectral scanner carried in Landsat satellites.

Scanner: An optical device that recognizes dark and light dots on a surface, and converts this recognition, by means of a grid array, into a digital file. It can be used to convert "paper maps" to digital maps, but generally requires additional computer-aided manipulation and manual editing to produce digital data in proper formats.

Software: A general term for any of the programs that are run on a computer and that perform particular tasks. Software is typically read on the hard drive (installed), and run from there. General categories of software include database and spreadsheet software.

Spatial: Refers to features or phenomena distributed in space and, thus, having physical, measurable dimensions.

State Plane Coordinate System: A system of plane-rectangular coordinates established by the federal government. The system is used for defining positions of points on, above, or below the earth's surface in terms of x and y values directly related to geographic (latitude and longitude) coordinates. One or more zones exists for each state in the US (see New Hampshire State Plane Coordinate System).

Tabular Database: Attribute data arranged in row (records) and column (item) format.

Thematic Map: A map that displays the spatial distribution of a single attribute or a specific topic, such as property assessments, soil types, or crime locations.

Topography: The relief, elevation or shape of the earth in a given area.

Topology: The explicit definition of how map features represented by points, lines and areas are related. Specifically, issues of connectivity and adjacency of features are accounted for.

Trigonometric Leveling: The determination of differences of elevation by trigonometric means using observed vertical angles and measured or computed horizontal distances.

UNIX: An operating system currently in use in the workstation environment. Features of UNIX include the ability to run many processes simultaneously, allowing multiple users to use a computer running this operating system at one time, and the inherent ability to function on a network.

Vector Data: One method of storing, representing or displaying spatial data in digital form. It consists of using coordinate pairs (x,y) to represent locations on the earth. Features can take the form of single points, lines, arcs or closed lines (polygons) (see **Raster**).

Vertical Datum: A quantity which serves as a reference to accurately define vertical positions. In the United States, two predominant reference surfaces for elevation are the National Geodetic Vertical Datum of 1929 (NGVD 29) and the more recent and more precise North American Vertical Datum of 1988 (**see Datum**).

Wide Area Network (WAN): A communication system that connects computers across a wide geographic area, such as across a state or between countries.

Workstation: A term used to refer to a class of computers that is typically high performance, single to several user systems and that often includes both high-resolution graphics and the ability to function within a network.

Appendix 2
Selecting a Consultant

1. Why do you need a consultant?

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2. What criteria will you use to evaluate the consultant's qualifications?

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3. What specific tasks do you want the consultant to perform?

____ user needs assessment
____ aerial photography
____ base map development
____ parcel/tax map development
____ software/hardware recommendations
____ software/hardware purchase training
____ GIS system design
____ database development
____ turnkey system

4. What credentials do you consider important in a consultant?

____ education
____ GIS experience
____ experience with local government
____ opinions of previous clients
____ quality of work samples
____ internal capacity to do work

5. Define project responsibilities:

a. Your responsibilities

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____

____

b. Consultant's Responsibilities

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6. What role(s) do you want the consultant to play?

____ analyst
____ advisor/provider
____ collaborator
____ facilitator
____ trainer
____ implementor

7. What contractual arrangement is acceptable?

a. Fixed-Fee (describe terms/conditions)

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b. Per Diem (describe arrangement)

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8. What qualities in a consultant are acceptable?

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9. How much money have you budgeted for a consultant? For how long?

____

____

____

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Appendix 3
Suggested Reading

Articles, Books and Reports

Antenucci, J.C., K. Brown, P. Croswell, and M. Kevaney. Geographic Information Systems: A Guide to the Technology. New York: Van Nostrand Reinhold, 1991.

Clapp, J. "Geographic Land Information Systems: State Perspective." Journal of Land Surveying, 117:3 (August 1991), 117-122.

Geographic Information Systems for Municipal Government Operations in the Housatonic Valley Region. Regional Planning Bulletin No. 72. Brookfield, CT: Housatonic Valley Council of Elected Officials, April 1993.

Implementation Plan for a Regional Geographic Information System. Atlanta, GA: Atlanta Regional Commission, September 1990.

Korte, George B. The GIS Book, 3rd ed. Sante Fe, NM: OnWord Press, 1994.

Land Systems Corporation. The Design and Implementation of a Geographic Information System for the Town of Rye, New Hampshire. Concord, NH: NH Office of State Planning, January 1990.

Lee, Jack. "Integrating Attribute Data and Graphic Data: A Case Study of a Successful GIS Pilot Project for Dover, NH." URISA '88: Mapping the Future, 1 (1988), 109-116.

Lincoln Institute of Land Policy. "GIS in Northern New England Cities and Towns." in GIS in New Hampshire's Regional Planning Agencies. Exeter, NH: Rockingham Planning Commission, October 1988.

Map Uses, Scales and Accuracies for Engineering and Associated Purposes. Report of the ASCE Surveying and Mapping Division Committee on Cartographic Surveying. New York, NY: American Society of Civil Engineers, 1983.

Microcomputer Geographic Information Systems for Town Land Use Planning. Meredith, NH: Lakes Region Planning Commission, July 1988.

Multi-Purpose Geographic Database Guidelines for Local Government. Report by the ACSM-ASPRS Geographic Information Management System Committee. ACSM Bulletin, August 1989, 42-50.

New Hampshire GRANIT Data Catalog. Concord, NH: New Hampshire Office of State Planning and Complex Systems Research Center, UNH, September, 1994.

New Hampshire GRANIT Users Guide. Concord, NH: New Hampshire Office of State Planning and Complex Systems Research Center, UNH, September, 1994.

New Jersey GIS Resource Guide. Trenton, NJ: New Jersey State Mapping Advisory Committee, 1993.

Panel on a Multipurpose Cadastre. Committee on Geodesy. Need for a Multipurpose Cadastre. Washington, DC: National Academy Press, 1980.

Panel on a Multipurpose Cadastre. Committee on Geodesy. Procedures and Standards for a Multipurpose Cadastre. Washington, DC: National Academy Press, 1983.

Sloan, Peggy, Julius Fabos, and Jack Ahern. Improved Land Use Decision-Making in Rural Communities: GIS in the 1990s. Massachusetts Agricultural Research Station Research Bulletin Number 739. Amherst, MA: University of Massachusetts at Amherst, 1991.

Standard on Cadastral Maps and Parcel Identifiers. Chicago, IL: International Association of Assessing Officers, January 1988.

Standard on Facilities, Computers, Equipment, and Supplies. Chicago, IL: International Association of Assessing Officers, January 1989.

The Local Government Guide to Geographic Information Systems: Planning and Implementation. Washington, DC: Public Technology, Inc., the Urban Association and ICMA, 1991.

Thum, P.G., Vastag, P.H. and Niemann, Jr., B.J., Land Information System Database Design for Local Government. Madison, WI: University of Wisconsin-Madison, Land Information & Computer Graphics Facility, 1993.

U.S. Department of Commerce. Multipurpose Land Information System: The Guidebook. Rockville, MD: Federal Geodetic Control Subcommittee, 1994.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration, The MPC - Multipurpose Cadastre. Washington, DC: June 1987.

U.S. Department of the Interior, U.S. Geological Survey, National Mapping Division. Large-Scale Mapping Guidelines. USGS Open File Report 86-005. Washington, DC: American Society for Photogrammetry and Remote Sensing and the American Congress on Surveying and Mapping, 1986.

Ventura, S.J. Implementation of Land Information Systems in Local Government - Steps Toward Land Records Modernization in Wisconsin. Madison, WI: Wisconsin State Cartographer's Office, 1991.

Vonderohe, A.P., R. Gurda, S. Ventura, and P. Thum. Introduction to Local Land Information Systems for Wisconsin's Future. Madison, WI: Wisconsin State Cartographer's Office, 1991.

Warnecke, Lisa. "State Geographic Information Activities." ACSM Bulletin. Washington, DC: American Congress on Surveying and Mapping, April 1990, 35-39.

Warnecke, L., Johnson, J.M., Marshall, K. and Brown, R.S., State Geographic Information Activities Compendium. Lexington, KY: The Council of State Governments, 1992.

Wiggins, L.L. and S.P. French. GIS:Assessing Your Needs and Choosing a System. Planning Advisory Service Report No. 433. Chicago, IL: American Planning Association, 1991.

Periodicals

Cadalyst
Advanstar Publications, Inc.
859 Willamatte Street
Eugene, OR 97401

GEO Info Systems
Aster Publishing Corporation
859 Williamette Street
PO Box 10460
Eugene OR 97440-2460

GIS World
GIS World, Inc.
155 E. Boardwalk Drive
Suite 250
Fort Collins, CO 80525

Government Technology
GT Publications, Inc.
9719 Lincoln Village Drive
Suite 500
Sacramento, CA

PC Magazine
Ziff-Davis Publishing Co.
One Park Avenue
New York, NY 10016-5802

Appendix 4
Current GIS Education and Training Opportunities

There are several GIS education and training courses offered by New Hampshire colleges and universities, and private-sector vendors throughout New England. The following is a partial list of several programs and contacts for detailed information.

Education (in New Hamsphire)

University of New Hampshire

Department of Natural Resources

Course:	"Geographic Information Systems in Natural Resources" NR 760)
Credits:	3
Offered:	Spring Semester Day Classes
Prerequisites:	Instructor's permission
Contact:	Russell Congalton, 603-862-4644

Thompson School of Applied Science

Course:	"Introduction to Geographic Information Systems" (Civil Technology 246)
Credits:	3
Offered:	Spring Semester, Day Classes, Division of Continuing Education
Prerequisites:	Knowledge of DOS, Instructor's permission
Contact:	Robert G. Moynihan, 603-862-1059

Plymouth State

Department of Geography
Department of Computer Science

Contact: Bill Taffe, 603-535-2530

Keene State

Department of Geography

Contact: Klaus Bayr, 603-358-2507

New Hampshire Technical College, Berlin

Contact: David Carlisle, 603-752-1113

Training (in/out of State)

University of New Hampshire

Thompson School of Applied Science GIS/CAD Laboratory

Courses:	GIS Software (PC ARC/INFO and ArcCad), CAD Software (AutoCAD)
Contact:	UNH Division Continuing Education, 603-862-2015

New Hampshire Technical College, Stratham, Manchester, Concord

Course: AutoCAD Training

University of Vermont, Burlington

Contact: Division of Continuing Education, 802-656-2088

Salem State College, Salem, MA

Contact: Bill Hamilton

Private-Sector Vendors

Most software vendors offer training courses in their own GIS software. Contact them for information about their public offerings and schedules. Also, GIS consultants offer training upon request.

Appendix 5.
United States National Map Accuracy Standards

With a view to the utmost economy and expedition in producing maps which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined (by the US Bureau of the Budget) as follows:

1. **Horizontal Accuracy.** For maps on publication scales larger than 1:20,000, not more than 10 percent of the points shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as bench marks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings), etc. In general what is well defined will also be determined by what is plottable on the scale of the map within 1/100 inch. Thus while the intersection of two roads or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable with 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scales closely upon the map. In this class would come timber lines, soil boundaries, etc.
2. **Vertical Accuracy,** as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.
3. **The accuracy of any map may be tested** by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.
4. **Published maps meeting these accuracy requirements** shall note this fact on their legends, as follows: "This map complies with National Map Accuracy Standards."
5. **Published maps whose errors exceed those aforestated** shall omit from their legends all mention of standard accuracy.
6. **When a published map is a considerable enlargement** of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."
7. **To facilitate ready interchange and use of basic information for map construction** among all Federal mapmaking agencies, manuscript maps and published maps, wherever economically feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, or 7.5 minutes, or 3-3/4 minutes in size.

Issued June 10, 1941; Revised April 26, 1947. Source: Multipurpose Land Information System: The Guidebook, October 1989, pp. 2-17.

Appendix 6
ASPRS Interim Accuracy Standards for Large-Scale Maps

Horizontal map accuracy is defined as the rms (route mean square) error in terms of the project's planimetric survey coordinates (X,Y) for checked points as determined at full (ground) scale of the map. The rms error is the cumulative result of all errors including those introduced by the processes of ground control surveys, map compilation, and final extraction of ground dimensions from the map. The limiting rms errors are the maximum permissible rms errors established by this standard. The limiting rms errors for Class 1 maps are listed below. These limits of accuracy apply to tests made on well-defined points only.

Planimetric (X or Y) Accuracy (limiting rms error, feet)	**Typical Map Scale**
0.05	1:60
0.1	1:120
0.2	1:240
---------- [1]	
0.3	1:360
0.4	1:480
0.5	1:600
1.0	1:1,200
2.0	1:2,400
4.0	1:4,800
5.0	1:6,000
8.0	1:9,600
10.0	1:12,000
16.7	1:20,000

Planimetric (X or Y) Accuracy (limiting rms error, meters)	**Typical Map Scale**
0.0125	1:50
0.025	1:100
0.050	1:200
---------- [1]	
0.125	1:500
0.25	1:1,000
0.50	1:2,000
1.00	1:4,000
1.25	1:5,000
2.50	1:10,000
5.00	1:20,000

[1]Indicates the practical limit for aerial methods; for scales above this line, ground methods are normally used.

Vertical map accuracy is defined as the rms error in elevation in terms of the project's elevation datum for well-defined points only. For Class 1 maps the limiting rms error in elevation is set by the standard at one-third the indicated contour interval for well-defined points only. Spot heights shall be shown on the map within a limiting rms error of one-sixth of the contour interval.

Lower Accuracy Maps

Map accuracies can be defined at lower spatial accuracy standards. Maps compiled with limiting rms errors of twice or three times those allowed for a Class 1 maps shall be designated Class 2 or Class 3 maps, respectively. A map may be compiled that complies with one class of accuracy in elevation and another in planimetry.

Root Mean Square Error

The root mean square (rms) error is defined to be the square root of the average of the squared discrepancies. In this case, the discrepancies are the differences in coordinate or elevation values as derived from the map and as determined by an independent survey of higher accuracy (check survey). For example, the rms error in the X coordinate directions can be computed as:

$rms_X = (D^2/n)$

where, $D^2 = d_1 2 + d_2 2 + \ldots + d_n 2$

$d =$ discrepancy in the X coordinate direction

$d = X_{map} - X_{check}$

$n =$ total number of points checked on the map in the X coordinate direction

The above materials are reproduced from Photogrammetric Engineering & Remote Sensing, copyright 1988, by the American Society for Photogrammetry and Remote Sensing, v. 54, no. 7, pp. 1079-1081.

Source: Multipurpose Land Information Systems: The Guidebook, October 1989, pp. 2-19.

Appendix 7
User Needs Assessment Questionnaire

Instructions

As you may know, [name of town or city] is considering a Geographic Information System (GIS) to help all departments manage and use the geographic information they need for a variety of purposes. The purpose of this questionnaire is to collect information about your department's current and potential geographic information needs regarding items such as maps, emergency services, and engineering drawings. The information you provide about your department's specific activities and responsibilities will be used to design an information system.

Please complete each of the questions in as much detail as you believe appropriate. However, the more detail you provide, the more comprehensive the results of this survey will be. Although this questionnaire is designed to elicit specific information, if you have additional comments or observations about your department's needs, include them, too.

Please return your completed questionnaire to Ms/Mr. [name] at [address] by [date]. If you have any questions, contact [person] at [telephone number].

Personal Information

Name: ______________________________

Title: ______________________________

Department: ______________________________

Tel: ______________ Fax: ______________

Department Information

1. Describe or diagram the organizational structure of your department.

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2. List the department's primary responsibilities and products.

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3. List the information your department shares with other municipal departments.

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4. List the information other departments share with your department.

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5. Identify compatibility related problems with shared data, such as for maps.

Department Data

6. Identify the types of data your department manages and uses.

7. Describe your department's data standards, quality assurance and quality control procedures.

8. Describe the department's currrent information system.

Department Activities

9. Briefly describe or diagram a recent department project for which geographic information was critical.

10. List the tasks you feel were redundant and/or time consuming, and explain why.

11. Describe ways this project could have been conducted more efficiently.

12. Identify the tools or techniques that were most useful in the conduct of this project, and explain why.

Map-Related Activities

13. List the types of maps the department currently uses or needs.

14. Identify the map scale or scales needed for specific map types.

15. Describe the level of accuracy needed for each map type.

16. Describe or diagram the procedure for updating department maps and the time required to do so.

17. List and describe the reasons for any problems related to generating new maps or updating existing maps.

18. Discuss whether or not your department's current map-related needs are being met.

19. If you believe that a computer-based information system will improve your department's ability to generate new maps and update existing maps, explain how and why.

20. List and describe briefly any analytic capabilities the department might need.

Database-Related Activities

21. List the techniques, such as cards, spreadsheets or database software, the department currently uses to store and retrieve data.

22. List the information contained in records, and how often records are updated and the updating procedure used.

23. Describe any problems your department staff have storing and retrieving information.

24. Describe new database capabilities your department could benefit from.

Computer System Information

25. If your department has a computer system, identify the hardware, software, and current uses.

26. If the system is meeting the department's current needs, explain why. If not, also explain why.

27. If your department does not have a computer system, identify the hardware, software and capabilities you would prefer to have.

Personnel Information

28. If you have a computer system in place, discuss the extent to which the staff are comfortable using it.

29. If the department does not have a computer system, discuss the methods you consider appropriate to help the staff learn how to use the system.

Appendix 8.
MUNICIPAL AND REGIONAL PLANNING GIS ACTIVITY IN NEW HAMPSHIRE

Municipal GIS Activity

The following is a partial listing, based on a 1993 survey, of towns and cities in the state that are working in some way with GIS. It provides a snapshot of current GIS activity. If your community is involved with GIS in some way and has not been listed, or if the information is incomplete or needs to be updated, please give Bob Moynihan a call at UNH (862-1059).

TOWN	CONTACT	ACTIVITY
Bedford	Karen White, Planner 472-5242)	Pilot area flown w/topo & planimetry; existing good-quality tax maps digitized; related databases being developed.
Berlin	Terry Block, City Engineer (752-3407)	Flight (1992) done; 2′ contours, base map (100′ urban, 400′ rural); tax maps - 1993.
Brookline	Sandra Fessenden (673-8855)	Digitizing tax map updates
Claremont	Peter Goewey, Public Works (542-7020)	Flight done, info "in can", ran out of money
Concord	Richard Perkins, Engineering (225-8520)	GIS operational in 1990; flight done; tax maps digitized; computer database developed for most departments complete; many map products.
Dalton	Selectmen (837-9642)	Remapping of town completed; digital planning maps under development.
Derry	George Sioras, Planning (432-6100)	Town flown in 1986 w/topo; tax maps and other mapping projects completed in 1992-93; building database.
Dover	Steven Stancel, Planning (743-6021)	GIS operational 1990; flight in 1987; tax maps digitized; many map products; developing databases in building, assessor, planning departments.
Durham	Rob Houseman, Planning (868-5578)	Some digital map products completed; pilot study of parcel mapping w/GPS carried out in 1993.

Easton	Barbara Collier (823-5293)	Digitized existing photo-correct tax maps w/GeoSQL; added new assessors database.
Enfield	Julie Huntley, Selectmen's Office (632-4201)	Digital base map (100' urban, 400' rural) 1992 photography; digitized tax maps.
Exeter	Zachary Gordon, Planning (778-0591)	Digitized tax maps, map products in use; consider flight in 1994; use for planning database.
Gilford	John Bobula (524-6294)	1986 flight w/gnd. control, digitized new; researched tax maps.
Gorham	Selectmen (466-3322)	GIS needs analysis completed; digital data conversion in progress.
Hanover	Don Monroe, Assessing (643-4123)	Digitized tax maps using Generic CAD
Hollis	Peggy Gillette (465-2209)	1988 aerial photography; digital base (1"=200'); tax map digitized.
Hudson	Mike Gospodarek, Engineering (886-6005)	Digitized tax maps, sewer maps, planning co-op venture w/Alvirne High School
Keene	Keith Damon (357-9802)	Flight done and topo (5'contours) and base map digitized; no tax maps digitized yet; (working w/Keene State College)
Lebanon	Robert Kline, Engineering (448-1451)	Flight done and base map (1"=100') digitized; tax maps digitized.
Littleton	Matthew Nazar (444-7078)	1985 flight w/gnd. control; researched and digitized new tax maps; added GeoSQL and assessing database.
Londonderry	Peter Curro	Roads from USGS maps digitized and registered to state plane coordinates; tax maps digitized, using roads as references.
Manchester Water Works	Tom Bowan (624-6494)	Digital base maps and water system; full CADD operation.
Manchester	Robert MacKenzie, Planning (624-6450)	Street and road map digitized; SCS soils overlay, water feature map, political wards, and zoning districts digitized.
Merrimack	Earle Chesley, Public Works (424-2331)	Some tax maps have been digitized; building department databases automated.
Milford	Mark Foguere, Planning (673-7964)	Roads and other maps automated for master plan update.

Nashua	Roger Houston, Planning (594-3360)	Started MIS/GIS, not operational, considering flight, building database, AutoCAD used in engineering department.
New Castle	Etolle Holzaepfel, Planning (431-6710)	Base map digitized; tax map digitized.
Pembroke	Michael Toepfer, Planning (485-4747)	Road map, zoning map being digitized
Portsmouth	Dave Allen, Public Works (427-1530)	Preparing to remap city.
Rochester	Peer Kraft-Lund, Planning (335-1338)	1992 flight, digital base (100' urban, 400' rural); GIS under development.
Rye	Don Stern	1989 flight, digital base map (1"=100'), topo (2' contour interval); tax map digitized.
Salem	Ed Blaine, Engineering (893-5731)	Working on developing GIS capabilities.
Somersworth	Norman LeClerc, Engineering (692-4262)	Base maps digitized; partial tax map digitization; some digitized sewer maps; investigating GIS options.
Wolfeboro	Amanda Simpson, Planning (569-5970)	GIS and aerial photography under development; update of tax maps planned.

NH Regional Planning Commission GIS Users

All nine regional planning agencies in the State have GIS capability.

The following are the contacts at each region who can assist communities with specific questions regarding GIS.

REGION	CONTACT	PHONE
North Country Council	James Steele	444-6303
Lakes Region Planning Commission	Doug Klock	279-8171
Upper Valley-Lake Sunapee Regional Planning Commission	Shelley Hatfield	448-1680
Southwest Region Planning Commission	Maureen Barber	357-0557
Central New Hampshire Planning Commission	Amy Parker	796-2129
Southern New Hampshire Planning Commission	Susan Nicosia	669-4664
Nashua Regional Planning Commission	Jeremy Ginsberg	883-0366
Rockingham Planning Commission	David Ahnert	778-0885
Strafford Regional Planning	David Wickliffe e-mail: strafford@mv.mv.com	742-2523

Please call Ken Gallager (271-2155) with any additions or deletions to the list.

Consultants

The Office of State Planning maintains a list of consultants and the services they provide. Communities interested in obtaining a copy should contact Ken Gallager or Jim McLaughlin at (603) 271-2155. Consulting firms are asked to contact OSP to have information on their company added or updated to this listing.

Appendix 9

CHAPTER 76, LAWS OF 1994 (HB 1411)

76:1 New Section; Geographic Information Systems. Amend RSA 24 by inserting after section 13-b the following new section:

24:13-bb Geographic Information Systems.

I. Any county may establish computer-based geographic information systems and control the distribution of that information, subject to RSA 91-A. The county may finance the completion and perpetuation of the system through a special revenue fund or through nonprofit corporations. The county may charge fees for the use of the system.

II. Notwithstanding any other provision of law, for the purposes of paragraph I of this section, the county convention of any county, may vote to restrict revenues from a specific source to expenditures for specific purposes. Such revenues and expenditures shall be accounted for in a special revenue fund separate from the general fund. Any surplus in any fund created under this paragraph shall not be deemed part of the general fund accumulated surplus nor shall any surplus be expended for any purpose or transferred to any appropriation until such time as the county convention votes to appropriate a specific amount from said fund for a specific purpose related to the purpose of this section.

76:2 New Section; Geographic Information Systems. Amend RSA 31 by inserting after section 95-e the following new section:

31:95-f Geographic Information Systems. Any town may establish computer-based geographic information systems and control the distribution of that information, subject to RSA 91-A. The town may finance the completion and perpetuation of the system through establishing a special revenue fund under RSA 31:95-c and 31:95-d or through nonprofit corporations. The town may charge fees for the use of the system.

76:3 New Section; Geographic Information Systems. Amend RSA 47 by inserting after section II-b the following new section:

47:11-c Geographic Information Systems. Any city may establish computer-based geographic information systems and control the distribution of that information, subject to RSA 91-A. The city may finance the completion and perpetuation of the system through establishing a special revenue fund under RSA 47:1-b and 47:1-c or through nonprofit corporations. The city may charge fees for the use of the system.

76:4 Effective Date. This act shall take effect 60 days after its passage.

Approved: May 6, 1994, Effective: July 5, 1994